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MODERN MUSCLE TRAINING

A Condensed Study of Heterophoria and Methods of Treatment

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What of the Ocular muscles? Are methods of caring for them keeping pace with the advancement in other branches of optometry? Of what value are the new muscle tests, and to what extent have they broadened the field of optometric practice?

These questions are in the minds of many practitioners and it is possible that an impartial study of them may develop some facts of value.

We shall make two divisions of the subject. First, we shall consider the fundamental teachings which for many generations have been an accepted part of eye physiology, Secondly, we shall view those theories which in recent years have come to occupy an important place in the thought and practice of many optometrists.

Vision a Binocular Function

It has long been recognized that discomfort from ocular muscles is largely a result of binocular vision. The individual who has but one eye, suffers no fatigue of the extrinsic muscles. The eyes are poised in the orbits in beautifully lubricated capsules so that they may revolve without friction. Their movements are almost as free as if they were floating in water. It is evident, therefore, that little strength is required to rotate an eye ball. If there is fatigue it is not from this cause. Ocular fixation consists of directing the eye so that light from an objective source may encounter the macula. The person with but one eye may accomplish this either by moving his eye or his head and would quickly learn the position of the latter from which the eye may make comfortable excursions in all directions. Binocular vision, however, has greatly complicated this act. It has been both a blessing and a curse. It has greatly extended the range and improved the quality of vision but has introduced demands upon the nervous system which, in some cases, have been a serious handicap.

Fusion An Acquired Faculty

When both eyes are fixed upon the same point in space, the stimuli created at the maculae are conveyed to the primary brain centers in the right and left external geniculate bodies, thence are transmitted over afferent pathways to the right and left occipital regions, where occurs the

act known as fusion. This blending into one sensation of the visual impulses conveyed through the two optic nerves, is accomplished through intercentral fibers and undoubtedly is a product of habit. When the image in one eye falls upon different nerve cells from those of the companion retina, which receive a similar image, the result is diplopia. To the human this is exceedingly distasteful because through many ages he has cultivated single binocular vision. Animals that have their eyes located on the sides of their head are able to perceive different objects simultaneously, just as man is able to feel different objects with his right and left hands without confusion. Biologists tell us that man's eyes were originally so placed in the skull as to prevent single binocular fixation but that ages of evolution brought them to their present position. It is evident, therefore, that this remarkable faculty, fusion, has been evolved by gradual development and since it is an acquired faculty, we know it to be subject to the laws governing nerve reflexes and must study it from this point of view.

Muscle Sense

Let us now turn to consideration of certain facts of muscle physiology without which it is impossible to comprehend this subject. Muscles are supplied not only by efferent nerves from which they derive the power of motion, but they also have afferent connections which are responsible for sensation. These sensations do not always take the form of pain; they are sometimes similar to the sense of touch or feeling. Thus, the brain is made aware of the position of a muscle without observing its effect upon the appendage controlled. The blind musician knows by muscle sense the proper position at which to place the slide of his trombone, or how to operate his bow arm in playing a violin. In like fashion the position of the eyes in the orbit is realized by the mind, not through the character or position of the images upon the retina, but from the "feel" of the ocular muscles as they move into position for binocular fixation. Various forms of deception may be practiced upon an individual by means of prisms, mirrors and other devices which serve to trick the muscle sense. An illustration of this is seen in the use of prisms, bases out, before the eyes, which are fixed upon the test chart at six meters. As the power of these prisms is increased to approximately the fusion reserve limit, the letters of the chart appear greatly diminished in size. This phenomenon is due to the fact that our judgment of size is affected by our concept of distance. Since the prisms induce the "feel" of fixing a near distance, the letters assume the size they would have to be to form so small a retinal image at that distance.

Educating the muscle sense is one of the essential factors in a course of training to correct crossed eyes. Any method or device, whether surgical or optometrical, which seeks to correct strabismus with-

out providing this education, leads to confusion and usually causes the patient to shun the binocular vision which is so important to success.

Muscle Tonus

A property of muscle which perhaps is as important to our study as any other, is that of tonus. This name is used to describe that action which maintains a state of partial contraction in healthy muscles at all times. It is accomplished by involuntary nerve stimulus and serves to keep all of the muscles in readiness for instantaneous contraction. It may be said to take up the slack of the muscles which normally are too long when in a state of relaxation. Since this is produced by nerve action, it is obvious that it may become deranged.

One form of improper tonus is partial or total paralysis. The result of this may be readily observed. If certain facial muscles are paralyzed, the features appear distorted because of the tonus of other antagonizing muscles. If one of the ocular muscles becomes paralyzed its antagonist instantly draws the eye to the opposite position. This shows that when the eyes are in a state of repose none of the muscles are relaxed. The partial contraction of each is counteracted by that of some other. Another form of derangement of tonus is abnormal nerve stimulus producing what is known as muscle spasm. This may result in various forms of cramp both in the eyes and over the body in general. It is responsible for many forms of muscular imbalance and must, therefore, be given careful study.

Fatigue

One of the important causes of spasm is fatigue. Fatigue is that condition in which it becomes difficult for muscle fibers to receive nerve stimulus. This difficulty grows out of the fact that repeated stimulation causes fatigue poisons to accumulate around the nerve terminals, thus preventing their proper function. When stimulation is discontinued the blood supply begins its process of neutralizing and absorbing the fatigue poison and as soon as it is all carried away we say the muscle has become rested. Involuntary muscles which do not receive their stimuli through the same manner of nerve terminals are less subject to fatigue. Some of these, such as the normal heart muscle, are capable of working an entire life-time, with only momentary rest periods between contractions, without becoming fatigued. The ciliaries, which also are involuntary, are capable of contraction through every waking moment and unless the demands upon them are excessive, show no signs of fatigue. The extrinsics, however, are voluntary muscles and these, like the leg muscles, must have frequent rest periods, and though they may be developed to a point where they can endure prolonged strain, they are always subject to fatigue and if seriously overtaxed, their efficiency becomes impaired.

Primary Eye Movements

Let us consider the actions in which the eye muscles are least liable to be strained or to reveal any previously acquired weakness. Certain movements have always been executed more than others. These are the primary excursions which maintain binocular vision. Countless generations of usage have established their nerve paths. These congenital pathways are very definite. Through one of them the superior recti muscles are joined so that when one muscle is contracted, the other automatically contracts also. In like manner the inferior recti receive simultaneous impulses so that the effort to lower one causes lowering of both. A more complex relationship is that between the internal rectus of one eye and the external rectus of the other. If an object to the right is to be fixed the right external and left internal recti must contract simultaneously. If to the left, it is the left externus and the right internus which coordinate. These actions are possible because the centers which control them are joined by intercentral fibers. The sixth nerve nucleus is automatically united with the nucleus which controls the left internal rectus branch of the third cranial nerve, so that a single impulse, originating at the sixth nucleus and transferred by intercentral fibers to the proper nucleus of the third nerve center, operates, in unison, the internal rectus of one eye and the external rectus of the other. When the eye muscles act in any of these correlated movements they have equal strength. They can turn the eye-ball up, down, to the right or left, through an arc of at least 45 degrees in each direction. This means a rotation equal to the deviating power of 100 △ prism base up, down, in or out. To appreciate this strength one may close his eyes, place a finger firmly against the temporal side of the right eye and endeavor to restrain it, while attempting to turn both eyes to the right. The pull of the muscle against the finger is fully as great as that of the internal muscle of the companion eye, as can be proved by attempting to restrain it in like manner. Testing the superior and inferior recti muscles in this fashion shows them to possess the same strength as the lateral muscles.

Muscle Power

It is important that we understand the full significance of power in muscle. This depends upon the potential energy which can be directed to it and its mechanism for receiving and responding to it. In some instances apparently weak muscles are capable of exhibiting great power. A striking instance is that of the sick person who, though wasted by disease until his muscles are reduced almost to the size of mere tendons, is able, under the delirium attending fever, to put forth such great physical effort that several persons are required to restrain him. Small frail women under the influence of violent insanity sometimes perform feats

of strength which would be impossible to them in a normal condition of the nervous system. Thus, we see that the contracting power of a muscle depends, primarily, upon one's ability to concentrate energy to it. It is equally true that involuntary action of muscle depends upon the character of its nerve supply for the greater part, though to some extent, it is influenced by the presence or absence of fatigue poisons in the muscle.

Accommodation and Convergence

The action which, perhaps more than any other, taxes the ocular muscles is that by which near objects are fixed and focalized. In viewing such objects, each eye must be so rotated as to bring the macula into position to receive its light. At the same time the ciliary muscles must adjust the accommodation of each eye so as to form a distinct image upon the retina. Under normal circumstances accommodation is only needed when viewing objects near by, which necessitates convergence also. Since binocular vision began, the eyes have been operated in this relationship so that a congenital coordination has come to exist between accommodation and convergence. The muscles involved in this relationship are not natural associates. The recti muscles are composed of striated fibers such as are found in voluntary muscles, while the ciliaries are plain: these being the involuntary type. The internal recti receive their stimuli from the third cranial nerves. The ciliaries are stimulated from the ciliary ganglion, one root of which is sympathetic, one sensory and the other, a branch of the third cranial also. Their nuclei, however, are both located in the third nerve center. Through long continued coordination, nerve paths have been established between the nucleus for accommodation and that for the internal rectus so that an impulse directed to the ciliary muscle has been found to excite a somewhat similar impulse to the internal rectus, except when the latter is in some manner inhibited. This fact has given rise to the following theorem:

"Accommodation and convergence are related in action, but this relationship varies in different individuals and in the same individual is undergoing constant change."

In explanation we would remark: first, that different individuals have different interpupillary widths, different ocular muscle attachments and different qualities of muscle control. Secondly: every individual is subject to constant change in the action of accommodation. The crystalline lens begins a process of hardening in youth and continues changing through life to the point of total solidity. As the lens hardens the work of the ciliary muscle increases, in performing the duties of accommodation. It may be stated that the same amount of accommodation requires increasing amounts of ciliary action through the years, until in old age

a condition is reached in which one diopter of accommodation requires as much contraction on the part of the ciliary muscle, as in youth was needed for eight or ten diopters.

While accommodation is thus becoming more difficult the task of convergence is actually growing easier. This, because the more frequently a muscular action is performed, the more efficient the muscle. There is, of course, a limit beyond which this rule would cease to apply but, nevertheless, it is evident that as accommodation grows more difficult, convergence becomes somewhat easier, making it necessary for their relationship to undergo a constant readjustment.

Presbyopic Border Line Important

The time of life at which this readjustment is of greatest importance is probably between the ages of thirty-five and forty-five. During this period the effort of accommodation shows a marked increase even when the conditions of general health are normal. It becomes necessary to employ a form of relative accommodation for average reading distances, as the ciliary muscle must now contract itself in a manner which in former years was sufficient to produce a focus at five or ten inches. This task, difficult as it is, may usually be accomplished, unless unreasonable demands are made upon the eyes for close work. If at this stage the muscles be tested, it will almost invariably be found that accommodation for the normal reading distance of approximately forty centimeters, will excite an involuntary convergence for a point much closer than this:—possibly twenty-five centimeters; so that in near work a constant inhibition of over-convergence is necessary. This effort contributes somewhat to the fatigue which at this age even normal eyes experience from excessive close work. It has been found that in the early period of presbyopia, otherwise normal eyes have their comfort greatly increased in close work by the use of prism, base out, as a substitute for plus spheres. Experiments have shown that though at first these may be mild, they must be used with increasing strength as the presbyopia increases. It may be definitely stated that this fact has no clinical value but is merely of interest to the student. Even though the use of prism, base out, may give identically the same degree of comfort as plus spheres which suspend over-accommodation, there could be no possible justification for their use. The spheres are always to be preferred inasmuch as over-accommodation is something of a menace even to one who seems to accomplish it comfortably. Years ago the writer likened this practice to the attempt to produce harmony in a family where there is discord, due to the extravagant habits of the husband, by cultivating like habits on the part of the wife. A proper correction for presbyopia consists of plus spheres which permit accommodation to employ just half of its total amplitude at the average reading distance. This allows the ciliary

muscle to contract in approximately the same manner to which it has been accustomed and in the relation it bore to convergence before the approach of presbyopia.

Causes of Esophoria and Exophoria

But now let us consider those things which may interfere with normal muscle balance. It is obvious that the first of these is ametropia; particularly hypermetropia and myopia. Both of these ocular defects introduce a disturbing element into the relationship between accommodation and convergence. Hypermetropia, of course, is the more important because it necessitates over-accommodation at all times and distances. The ciliaries must adjust the focus for distant objects, while the extrinsic muscles continue to hold the visual axes approximately parallel. This necessitates the use of relative accommodation which in time is invariably fatiguing. When objects near at hand are to be viewed, accommodation is required in excess of the amount needed for the distance, by the amount of the hypermetropia. This excess is relative accommodation and again we see it affecting convergence because the eyes must carefully fix upon the object viewed and any tendency to overconvergence in sympathy with the relative accommodation, must be inhibited.

There are many evidences that this constant use of over-accommodation develops an involuntary nerve impulse to the internal recti. Sometimes this impulse is of like amount with the relative accommodation, sometimes it is greater, but oftener it is less. The conditions which determine this variety of effects have never been ascertained. It is generally accepted that this tendency of the eyes to converge which we so frequently find associated with hypermetropia, is the result of increased tonus of the internal recti. Frequently it is of no consequence though occasionally it may cause discomfort. The fact of relative accommodation being responsible for esophoria is clearly established by the result of treatment. Countless cases have occurred in which plus spheres have caused a gradual reduction of the tonus of the internal recti, resulting in suspension of the esophoria entirely or in part. Other extreme cases are not uncommon in which excessive amounts of hypermetropia have incited convergent strabismus which corrected itself as soon as the plus spheres were applied to remove the relative accommodation.

We have said that myopia also disturbs the balance of the extrinsic muscles. This is only true where the eyes are used for close work. Such eyes see near objects with less than normal accommodation or none. This necessitates fixation by relative convergence, either entirely or in part. Inasmuch as relative convergence is not a congenital reflex, it causes fatigue which invariably contributes to weakness. It is but natural, therefore, that such cases have a diminished tonus and under test usually show an actual tendency of the eyes to diverge from each

other. The influence of accommodation in these derangements is again shown by the effects which usually attend correction of the myopia. If this correction be full so as to permit normal use of accommodation it will be found that over a period of time the tonus of the internal recti will increase and the exophoria disappear entirely or in part.

Extreme Cases Rare

The forms of imbalance which have been described constitute the great majority of the cases which are encountered by the optometrist. If these constituted all of the varieties of muscular imbalance, the task of dealing with them would be comparatively easy. Unfortunately, this is not true. There is a small, undetermined percentage of cases, the character of which makes them more or less difficult to handle. Some are relatively unimportant as they cause the patient but slight inconvenience. Others contribute to varying degrees of distress, ranging from persistent symptoms of headache and asthenopia to extreme nervous derangement, attended, in some cases, by violent nervous disorders, even resulting in mental or physical collapse. The optometrist may pursue his practice over a period of years without being consulted by any of these extreme cases, or again it may be his lot to encounter many of them. A successful practice may be built and maintained without catering to this type of cases; those who chance to come being referred elsewhere. It goes without saying, however, that one such patient successfully relieved, may do more toward building the reputation of the optometrist in a community than a score of the ordinary type. Furthermore, the joy of a difficult task well performed is realized in unusual measure by the man who solves one of these problems, beside the satisfaction of restoring the sufferer to a degree of health and comfort which no other treatment could give.

Less Common Types

We will first consider the different forms of vertical imbalance. These are the cases where in a state of repose, one eye rotates to a slightly higher position than its mate. As one contemplates hyperphoria he recognizes the difficulty of definitely identifying its cause. We will list some of the possible causes of which there is no doubt. The first is, partial or total paralysis. These are due to some lesion which cuts off the nerve supply. It may be at the nerve center or somewhere along its tract. Sometimes it is the result of a ruptured blood vessel producing a slight clot. Again, it may be some toxin which has gotten into the blood stream and has been carried to a point where it could attack the nerve or its center. Cases of partial paralysis are more generally of the latter type. The chance of recovery, as with all other conditions of this character, depends upon removal of the cause.

Anatomical Causes

Sometimes hyperphoria is caused by structural imbalance. Anatomists know that nature often fails short of perfection in the building of muscular tissues. Muscles vary in different individuals and in various parts of the same body. In one case they may be short and bunchy, in another they are long and sloping. These and other anatomical differences have an effect upon their efficiency. The ocular muscles for the most part are attached to Zinn's ligament, at the apex of the orbit. They pass forward and are inserted in the eye-ball at different distances from their base of attachment. No two of these muscles are exactly the same length, though the superior and inferior recti approach more nearly to this ideal than any others. Considering the wide range of abnormalities among the muscles of faces, shoulders, hips, arms and legs, anatomists have recognized the probability of like mistakes in the poise of the ocular muscles. If a superior rectus, for example, should have a tendon that is one millimeter too short, or is inserted in the sclera one millimeter too close to the cornea, the eye-ball must inevitably have a tendency to rotate to a position above its mate. This tendency must be counteracted by a constant increase of tonus in the inferior rectus of this eye. In some instances, where health is robust, the nervous system vigorous and the eye habits normal, this increased tonus is maintained so successfully as to prevent any indication of imbalance, even under test. In less favorable conditions fatigue would have its effect upon the inferior rectus, causing it at every opportunity to assume a position of rest. It is obvious that a malattachment of the superior rectus, in which its insertion is too far from the cornea, would cause this eye to tend to a position below its mate, which, of course, must be prevented by increased tonus of the superior rectus. If both superior recti were inserted an equal amount too far from the cornea, the result must be a tendency of both eyes downward, a condition described as kataphoria. If their attachment were an equal amount too close to the cornea, both eyes would have a tendency upward, known as anaphoria.

These are illustrations of all the varieties of imbalance which may be caused by anatomic anamoly. In some cases, they may be so extreme as to cause actual deviation or in other cases so slight as to be totally concealed. Since all muscles, when relaxed, have a certain amount of slack, it becomes apparent that muscle tonus conceals a multitude of structural defects of varying amounts. If they are slight, they may remain permanently concealed. If they are on the border line, they may be revealed occasionally, perhaps under the influence of fatigue. Greater amounts may be manifested at any time by tests, while extreme cases are constantly manifest.

Lateral Imbalance Against The Rule

Under this heading we would list exophoria associated with hypermetropia and esophoria associated with myopia. The treatment of these cases, as well as their cause, differs radically from those cases "with the rule." Let us first consider exophoria with hypermetropia. When such a case presents itself to the optometrist, he is indeed fortunate if he can obtain an exact history by which to determine something of the stages of its development. Possibly it was originally a case of esophoria and because of some manner of partial paralysis, was converted into exophoria. Or perhaps it is a case of anatomic imbalance. If the latter, one would assume that it was originally of greater amount, but gradually decreased through association with hypermetropia. Whatever the cause, it usually can be assumed that the amount would be greater were it not for the influence of the hypermetropia. In practically every case we find that plus spheres cause an increase in the imbalance with serious discomfort unless steps are taken for its correction.

Esophoria with myopia is equally unusual though not so troublesome. In these cases, convergence is employed in excess of accommodation. To illustrate; a myope of 2 D. would read at 1-3 meter with 1 D. of accommodation, combined with 3 M.A.^{0} of convergence. Such a patient holds his reading text at nearer distances; often as close as 5 inches. The explanation of this fact is that he moves the text closer in an effort to bring accommodation into harmony with convergence. The latter permits itself to be overtaken only as its punctum proximum is approached. This practice tends to build up the tonus of the internal recti, thus establishing a new relationship of convergence to accommodation producing the esophoria.

Imbalance at Near

In our description of the various forms of muscular imbalance, we have made mention of the fact that the relation of accommodation to convergence is constantly changing. We also remarked that this becomes something of a problem as the presbyopic border line is approached. During the past generation or two, the practice has developed of testing the balance of the eyes at the reading distance. Various methods have been devised for making this test but the commonest is to produce diplopia by the use of vertical prisms. If accommodation and convergence are in normal balance and the eyes are focused upon a target at 16 inches, we would expect that a 6 △ prism, base down, over one eye would cause the target, seen by that eye to appear directly above the target seen by its mate. Experience has shown, however, that it is usually necessary to use about 6 △ prism, base in, to bring the targets to the same vertical plane. This proves that normal eyes, when disassociated in this manner, have a tendency to swing toward parallelism of the axes even while

accommodation continues to act. We, therefore, characterize this deviation as the normal lag of convergence behind accommodation. We consider it normal because physiology teaches that healthy muscles have a tendency to lag whenever it is convenient for them to do so. Absence of lag is a sure sign of nervousness. The individual who is constantly tense is not well. One who takes a seat and proceeds to hold the chair instead of letting it hold him, has a deranged nervous system. If convergence fails to lag at every opportunity, we should seek the cause. An explanation which appears to be sound is that "when the eyes are orthophoric or esophoric at the near point, convergence is being unduly stimulated by an induced action which accompanies abnormal effort of accommodation." There may be two causes for this. First; it could be the result of premature hardening of the crystalline lens. The ciliary muscle, in order to produce a focus at 16 inches, is compelled to contract in a manner that should be sufficient for a much nearer distance; possibly 8 or 10 inches. Convergence displays its usual lag and fixes a point somewhat beyond this hypothetical distance, but inside of the point, which is actually being focused. The other cause might be impaired efficiency of the ciliary muscle. It may possibly be affected somewhat by toxins from a focal infection, or some other cause of lesion, producing a slight touch of paralysis. This would necessitate greater effort in performing its normal function, and convergence would be induced to act correspondingly. A test of the muscle balance at the near point, must be preceded by a test at infinity, and allowance made for static esophoria or exophoria in our analysis.

Methods of Treatment

The optometrist must endeavor constantly to perfect his skill as a diagnostician. He must learn to differentiate between those forms of imbalance which need treatment and others which are better off without it. In a Spanish graveyard is a tombstone upon which are inscribed the words: "I was well, would be better; took physic and died." This is a striking warning against unjustified experimentation. Hosts of patients have been made miserable by the practices of some zealot who had radical theories to which he subjected them. Many such theories have to do with methods of practice which directly contradict each other. A suffering patient is exceedingly fortunate if he comes under the care of an optometrist who has the resourcefulness and courage to employ any method of treatment which the case may require, but whose intelligence and experience have also taught him what not to do. There is a universal law which may be accepted as sound physiology; that is, "natural means are always best if they can possibly be made to succeed." We know that there are only two forms of treatment for any variety of muscular trouble. One is "rest," the other is "exercise." Of these, the more important is "rest."

Rest Treatment

It would be difficult to exaggerate the benefits that have resulted from relieving muscles and nerves from strain. We would list this as the first need in every case. Correcting glasses, if properly worn, are sufficient treatment for the great majority of cases of esophoria associated with hypermetropia and exophoria with myopia. Sometimes before prescribing these glasses, we require a hypermetrope to wear treatment glasses which, for a period of days, convert his hypermetropia into an artificial myopia of about 1 D. This causes readjustment of the relation between accommodation and convergence, prevents a large portion of the customary accommodative action and promotes relaxation and rest of the ciliary muscles. After a correction obtained in this manner has been worn for a time, esophoria will usually be found to have diminished and discomfort from this source disappears. This practice may well be adopted as a routine procedure as it contributes greatly to professional success.

A modification of this method consists of using before each eye, from 1 △ to 2 △ prism, base in, combined with the spheres which produce artificial myopia. This treatment might be indicated for those cases in which severe accommodative spasm is suspected. Use of such glasses for near work would suspend both convergence and accommodation sufficiently to encourage rapid relaxation of ciliary spasm. The prisms should be removed from the combination, however, before treatment glasses are entirely discontinued, so as to allow a greater contrast between the accommodative and convergent effort and thus insure comfort when the proper correction is worn.

Another method of obtaining rest for strained ocular muscles and one the value of which cannot be over-emphasized, is long periods of sleep. Sometimes the patient tries by glasses and exercises, to obtain comfort when his real need is from nine to ten hours of sleep every night. Often he is getting but five or six. His fatigued muscles do not have time to clear themselves of the acids and poisons from broken down tissue, caused by eighteen hours of continuous use. If such a case can be persuaded to spend ten hours in bed every night, he will be restored to a degree of health and comfort that eye treatment could hardly give. This is sound hygiene and the intelligent optometrist will recognize its importance in dealing with some of the difficult cases which have so tried his skill.

Prism Lenses

The last method of obtaining rest for ocular muscles, which we shall discuss, is the use of prism lenses. If these are applied intelligently, there are cases in which they enable the optometrist to achieve his greatest successes. If used unwisely they are of more harm than benefit. We know that a prism relaxes the muscle under its base, provided the

eyes continue to have single binocular vision. If this puts the muscles in balance, it will produce rest. If it puts them out of balance, it may cause misery. The commonest use of prism for rest purposes, is to correct hyperphoria. We have seen that there is no logical, physiologic reason for hyperphoria, inasmuch as the vertical muscles have no relation with either accommodation or convergence; even though they receive their stimuli out of the same general area of the brain. Cases of vertical imbalance have been known to improve as the general health is built up and they have sometimes gotten better after lenses are worn which correct over-accommodation. The reasons for this have never been definitely ascertained, though interesting theories have been advanced. Physiologists do not accept theories, however, unless they are supported by reasonable proofs. We, therefore, suspect hyperphoria of being produced by anatomic or pathologic causes. A safe rule to employ in dealing with it is to correct the error of refraction and counsel the patient as to rest, sleep and general health habits. If hyperphoria of 1 △ or more remains after the use of treatment glasses, it should be corrected with prism lenses, using the following rule: "Place before the eye which tends below its mate, the prism base up which under test, brings the two targets to the same horizontal plane." This should be prescribed for constant wear. If the strength of prism is 4 △ or more, the rule may be modified by using 2-3 of its strength, base up, and 1-3 over the companion eye, base down. This rule is based upon the fact that the eyes are more comfortable in a case of vertical imbalance, when allowed to turn more downward than upward, and a prism used in this manner permits both eyes to occupy a slightly lower position in the orbit.

Hyperphoria with Lateral Imbalance

Sometimes hyperphoria is combined with esophoria or exophoria. The lateral imbalance in such combinations should not be corrected; at least until after an attempt has been made to cure it by exercise. In certain instances, however, hyperphoric exophoria may be of such amount that the exercise fails and the exophoria also needs correction. In these cases, the greatest comfort is produced by use of prism, base up, before one eye and another prism, base in, before the other. It is usually best to correct all of the hyperphoria and all but about 1 △ of the exophoria, though sometimes this also demands correction in full.

Lateral imbalance without hyperphoria, rarely requires prism correction. Those cases which do demand it are usually exophoric. Anatomic imbalance of this type yields very slowly to exercise and sometimes a prism correction is needed, at least as a temporary measure. In cases of partial paralysis of the interni, it is necessary to prescribe reading glasses containing prisms, bases in. These are a relief measure and methods should be advised looking toward the restoration of the

patient's health. Prisms used in this manner may be added to bifocals or in separate reading glasses. The strength of this prism would usually equal the amount of the excess of near exophoria over 6 △, divided between the eyes.

Fusion Reserves

No branch of our subject has evoked more speculation or prompted more experimentation than study of the faculty known as the fusion reserve. In exercise of this faculty, the eyes are able to depart from their customary relationships to each other. Thus, while one eye remains fixed upon a given point, its companion is able to turn up, down, in or out, within a varying range. This faculty is normally involuntary. It is a by product of muscle tonus. The lateral muscles are accustomed to rather frequent variations of tension. Should an internus of one eye develop a spasm, the externus would involuntarily increase its traction to maintain equipoise. These variations of muscle tone are more common in the lateral muscles than in the verticals because they are accustomed to greater demands. The vertical movements of the eyes are more uniform. The purpose of all of these actions is to preserve fusion and they are performed as unconsciously as adjustments of the size of the pupil.

The simplest method of testing the fusion reserve is to interpose a prism in the line of vision of one eye. If this prism is base downward, the eye, to maintain fusion, must turn upward while the companion eye remains fixed. This is known as supraduction. Its strength in the average eye is 2 △. Infraduction is also 2 △. It is seldom that we find any departure from these figures except in a case of vertical imbalance, when the ductions would be thrown equally out of balance.

Prism, base in, before one eye, compels the eye before which it is placed to turn outward if fusion is to be undisturbed. This action is called abduction and its strength normally registers an average of about 6 △. Prism, base out, before one eye tests the adduction which also varies in healthy individuals. As a general rule adduction should be about three times as strong as abduction. Care must be observed in testing adduction to suppress accommodation. This is done by substituting test letters for the usual fixation light. The letters are the smallest that can be distinguished at 6 meters, so that the slightest amount of accommodation causes them to appear blurred. Prism, base out, is placed before the eye and increased until this blur first appears. The strength just short of this amount is the measure of adduction. Abduction and adduction are also modified by lateral imbalance and the latter must be corrected with prism before either can be properly measured.

Duction Tests at Near

We sometimes obtain interesting results by applying all of these tests while the eyes fix at the reading distance. Adduction and abduction occasionally show inconsistency when tested at the near point. In order to see an object singly at 40 centimeters, the average reading distance, the eyes must converge 15 Δ. If, from this position, they are able to adduct an additional amount equal to that shown at infinity, they must turn inward a total of 45 Δ. This would show unusual latitude between accommodation and convergence and is a very encouraging indication for the comfort of the eyes. The abduction test at the near point seldom produces evidence of value other than the extent of domination of accommodation over convergence and this is shown more accurately by the phoria test at the near point. If a pair of eyes can fuse 6 Δ, base in, at infinity, they should fuse 21 Δ at 40 centimeters, unless accommodation prevents the internal recti from relaxing. The first 15 Δ is required to suspend convergence and render the visual axes parallel, (provided the interpupillary width is 6 centimeters).

Methods of Treatment

We will now describe the methods of exercise which may be used for muscle training. As a preliminary it might be well to say a few words in explanation of exercise as distinguished from strain. Muscles, to be exercised, must be contracted, but this must be followed almost immediately by a rest period. Free circulation of blood is needed to carry off the fatigue poisons, created by muscle action. Blood vessels do not enter the muscle fibers but lie in between, parallel to them, so that the lymph which they give off can readily be absorbed by the muscle fibers. With each relaxation of a muscle a fresh flow of blood surges into it, to neutralize the poisons; this, in turn, to be driven out by the succeeding contraction, which compresses the muscle into a more or less solid mass and squeezes flat, the vessels which lie within it. The oftener this process is repeated the healthier the muscle becomes, because rapid circulation brings added building material and eliminates waste products. Furthermore, improved nerve control is established by repeated stimulation, alternated with rest periods.

Effects of Strain

In contrast with this action we see the harmful results of muscle strain. Strain is caused by muscular contraction which is sustained and is not broken up into frequent rest periods. Its injurious effects are not due to magnitude of effort but to the constancy with which it is maintained. When a muscle is held in a state of contraction, blood circulation is prevented and all of the injurious effects of accumulated fatigue

poisons result. The muscle is often weakened and in some cases is seriously impaired. It is evident, therefore, that any form of muscle training should exercise and not strain.

Stereopsis

We have seen that weakness of ocular muscles never seems to display itself, except in the acts by which fusion is maintained: That even those cases of extreme imbalance and weak duction display normal strength in all of the primary movements. These facts, supported by a large amount of experimentation, have given rise to a comparatively new theory in the field of eye training. This theory holds that stereopsis is the important element of binocular vision which dominates the fusion sense and inspires binocular fixation. Stereopsis is the faculty by which a third dimension is added to vision. Each retinal picture being flat, reveals nothing but length and breadth and as we have previously commented, it is difficult for monocular vision to perceive thickness or to judge the distance of objects. Of course, an approaching object undergoes a constant change in the size of the retinal image, the latter growing larger as the object comes near. In like manner, a receding object forms a retinal image which constantly grows smaller. The eye, by form sense alone, enables one to form a fair idea of the size of objects, through previous experience with similar objects, and to judge their distance by the size of the image. This judgment is aided somewhat by orientation, the faculty by which we determine the position of objects with reference to other objects and ourselves.

When these faculties are used binocularly, their powers are enhanced many fold. Through muscle sense and the ability to compare images formed upon other than corresponding points of the two retinae we judge distance, perceive depth and solidity, determine the size, position and motion of objects to a degree that is impossible without binocular vision. This faculty is called stereopsis.

Suspenopsia

Experiments of recent years have forced the conclusion that some eyes become indifferent to the advantages of binocular vision, particularly if one is somewhat defective. In these cases, there seems to be a rather loose habit of fusion, which permits an occasional suspension of the vision of one eye. Not that its retinal image ceases to produce a visual stimulus, but that this stimulus is in some manner disregarded. A similar action may be noted in the sense of hearing. An individual with a telephone receiver at one ear, may become totally oblivious of sound waves which impinge upon the auditory nerve of the companion ear. In like fashion; we may focus our attention upon objects in space and

become totally blind to surrounding objects, so that later, we have no recollection of having seen them; merely because they did not engage our attention. This power of selecting the image of one eye and ignoring that of the other, may have been acquired in the interest of conservation of energy. Proponents of this idea are stressing the importance of exercises for the cure of this vagary of vision known as suspenopsia. The best form of exercise is one which, for it's success, compels the eyes to function equally. This is accomplished by training sterescopic vision. The procedure for doing this is not complicated. All that is required, is an ordinary stereoscope and a set of stereoscopic pictures. The patient should view these pictures over and over, taking pains with each one, to perceive the solidity of the objects and to be conscious of the appearance of an actual landscape as only stereopsis can give it. If this practice is persisted in, the habit of fusion becomes more alert and it is contended that this form of exercise alone will serve as a cure, or at least eliminate the discomforts of muscular imbalance.

A modification of this method consists of setting up, in an ordinary phoropter, a set of prisms and spheres which produce stereopsis for the patient, then, while the eyes continue to hold stereoscopic vision, increase or decrease the prisms in a manner to exercise the ductions. Whatever virtue there may be in this method of exercise, its chief benefit must result from cultivation of the sense of fusion through stereopsis.

Instruments for Muscle Training

There are three distinct types of instruments which take rank over all others as suitable equipment for muscle training. They embody three distinct principles. One, which is perhaps oldest in principle, employs shifting prisms. The first muscle tests were made with loose prisms which were interposed in consecutive strengths before the line of vision. An improvement upon these was the prism bar, which contained an assortment of prisms, ranging in strength from 1 △ to 10 △ mounted, one above the other, with their bases all in the same direction. As this bar was raised or lowered before the eye its different prism strengths could be tried. Then came the instrument known as the Kratometer, which combined prism bars with prism wheels, but which retained the principle of causing the eye to shift from one prism to another of different strength.

The second instrument, known as the Phorometer, employs mobile prisms, which consist of two 15 △ prisms, mounted one before the other so that by the turn of a thumb screw their bases automatically change position with reference to each other. When their bases are in opposite position they neutralize each other and when in the same position, they give a combined value of 30△. At intermediate points, all intervening prism strengths may be obtained.

Both of these instruments employ a fixed target, either at 6 meters or at 40 centimeters and by using them systematically in a series of exercises, which consist of repeating the duction tests over and over, muscle balance may be improved and the eyes benefitted, by building up the circulation of blood and the supply of nerve force.

The third instrument employs a moving target which is a radically different principle in the field of oculetics. This instrument, known as the Myoculator, projects upon a screen a luminous target which is made to move in various directions and thus exercises the muscles of the eyes which follow it. It also possesses a unique device for taxing the ductions and holding them in this state while the eyes rotate through changing patterns to all portions of the orbit. This instrument also has its merits and, like the others, if used consistently, will accomplish the purposes for which it is designed.

It is not within the province of this paper to teach the technique of any instrument, but merely to present a study of the conditions needing treatment, their causes and the results which must be obtained for the treatment to be successful.

appendix muscle

Summary

~~We will now close with a brief resumé of the facts~~ of chief importance to one who seeks to practice ~~this~~ work intelligently.

First: Oculetics, or ocular gymnastics, are beneficial to all eyes, regardless of their state of balance, and if employed intelligently will contribute greatly toward the maintenance of efficient, comfortable vision.

Second: In any case of muscular imbalance "with the rule" the ametropia should be corrected in full and oculetics employed for all muscles alike.

Third: In a case of imbalance "against the rule" the ametropia should have a slight under-correction for a time, while oculetics are employed, stressing particularly an exercise of the ductions of the weaker muscles.

Fourth: Abnormal imbalance at near, not revealed at infinity, may be benefitted by general oculetics, together with attention to general health and possibly special correction at the reading distance.

Fifth: Vertical imbalance and all cases of exophoria which do not respond to treatment, should be corrected with prism lenses.

Sixth: All cases where suspenopsia is suspected and most cases of abnormal imbalance at the near point, should have stereoscopic training.

Seventh: As our final and most important rule, we would say: Beware of radicalism. In the words of Pope: "Be not the first by whom the new are tried, nor yet the last to lay the old aside."

A ROUTINE REFRACTION

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Accuracy in every department of eye work is naturally the ideal towards which we all strive and it is only by following a definite routine in an ocular examination that the greatest measure of accuracy can be attained. For the most part it makes little difference in the final result as to the order in which the tests are made providing they are *all* made, and made properly—however, unless one follows some sort of a systematic routine the chances of error are very great inasmuch as many of the small necessary check tests are apt to be forgotten, particularly during the busy hours of the day.

Time also is an important element and here again a definite routine assists the examiner because he always has at his fingertips the next instrument he wishes to use. There is never an awkward pause as he stops to review what has been done and to wonder just what to do next.

It therefore follows that the examiner with a well developed routine can do more and better work in a given time and the following outline of a routine refraction is herewith presented, not because of any new ocular phases to be presented or any new tests to be advised, but because the writer has found it an aid in solving the practical refractive problems presented in an optometric practice.

Eighty-five percent of all refractive cases naturally fall within the group composed of the hyperopes, myopes and astigmats of moderate degree, where an orthophoric or a nearly orthophoric condition exists. Presbyopia may or may not be associated with the above refractive conditions within this group, and it is with reference to refractions upon patients having one or more of these errors that a refraction which follows a definite routine can best be made.

Anisometropic cases, cases of retinal fatigue due to improper illumination or to a lack of retinal pigment, lens opacity cases, high myopic cases, squint cases and cases with a tendency towards a muscular imbalance, cases of subnormal or abnormal convergence and amblyopic cases all must be refracted independently of any routine and generally with a varying sequence of technic. Each case is, within itself, so different as to make a routine impossible, yet only fifteen percent of all cases fall within these latter groups, thus affording us a splendid opportunity of systemizing our work on the eighty-five percent, these being the average run of refractive cases.

Experience has proved that the most satisfactory results, in prescribing for ocular defects can be gotten by dividing the work into two periods. By this I mean a refraction, the objective portion of which is made during the first appointment and the subjective portion, with a re-check of the objective on the second day. This form of procedure is satisfactory to most people inasmuch as there are few patients who are loathe to grant the refractionist the time he asks to carefully correct and prescribe for their visual defects. This division of an ocular refraction is advantageous to both the examiner and the patient, for the latter, when called upon to sit through a complete ocular examination, taking an hour or more leaves the office in a rather fatigued condition, the latter portion of the refraction suffering thereby. By completing the refraction on the second day, one eliminates this difficulty, as most patients can easily stand two half-hour refractive periods with no show of discomfort or fatigue. The examiner likewise benefits from this division for it gives him time to mull over the pecularities of the case and to work out, a course of procedure to be prescribed, providing the second day's tests verify the work done at the first sitting. It therefore follows that a routine refraction divided in this manner will be obviously more thorough and the results more accurate than if completed at one sitting.

Nearly equal in importance to a thorough refractive routine is the matter of recording instrumental findings and other data from time to time, as the examination proceeds. There are many splendid standard record cards procurable of the five inch by eight inch size, most of them giving the examiner room for all necessary memoranda. A smaller card than this, is, as a rule, not satisfactory as it soon becomes too crowded for convenient use or reference.

The matter of records and their keeping is of such importance that it is well at this time to emphasize the need of recording the physical and physiological factors as revealed by the examination. Without this
3 complete record, one is helpless at some later date, when a patient returns with some abnormal condition, to determine the approximate onset of the abnormalty or to determine if same was present on previous visit. To merely use a record card to note the final formula prescribed along with a list of mechanical factors regarding the material used is to ignore the greater part of the value lying in optometric records.

After procuring a suitable record card the procedure would be as follows:

An office assistant fills in the Name, Address, Prescription number and Date on one of these record sheets, after which the case history is to be taken. This is obviously the duty of the examiner and it is at this point that he should step in and assume charge of the work.

The first step of the case history brings us to the vital matter of 5
1 *occupation.* This is so important in optometric work that the greatest
of care must be taken to carefully inquiring as to, not only the patient's
principal occupation but that of minor duties, as well as other factors,
which would require different individual focal points and it is at this
time, when discussing the patient's work, and hobbies, that valuable clues
are received, which can later be incorporated into an ocular prescription[1]
of real value to the patient. This will be more fully taken up later in
the paper so we will pass on to the next data to be secured from the
2 patient, that regarding *age.* This is not as necessary as it once seemed
to examiners, as dynamic skiametry has removed all need for the question,
still it is wise to tactfully inquire, the information becoming a sort of a
check upon the accommodative tests.

3 The patient's *nationality* is our next concern. This is important for
several reasons. First, specific types of refractive defects are more
prevalent among certain peoples than others, *i. e.*—Germans with myopia,
etc., second, the life long habits of people which may or may not effect
vision, *i. e.* the generally unsanitary conditions under which most peoples
from southeastern Europe live, and third, the prevalence of the infectious eye diseases, or their after effects among certain peoples, *i. e.*—
trachoma or the scars therefrom among the people from the Balkan
States[2]. This information regarding nationality is of interest as it may
help to explain conditions as they are later found.

4 We next inquire as to the *vision of the parents of the patient.* While
there seems to be a variance of opinion among refractionists on the
subject of heredity of such visual defects as squint and myopia[3] and of
such types of pathological deterioration as cataract[4]; certainly no examiner
of any experience will deny that refractive errors following certain
definite limits at least, and are frequently found running through two and
sometimes three generations of a family, thus making this question
quite imperative.

5 We next inquire regarding the patient's *health during childhood* with
particular reference to, first; accidents, second; to infectious diseases
such as measles and scarlatina. Optometrists are all familiar with the
injuries done to vision by ocular neglect during the course of these
6 diseases. The *patient's vision during childhood* is next inquired into
and anything of importance with regard to the patient's eyes as an infant or later as a small child is next recorded. *Conditions of eyes at the*
7 *start of school* logically follows and here one can record all data regarding
the vision of the patient while a student.

Many patients who are suffering in various ways and who hope, by
the use of an ocular correction, to eliminate much if not all of their
discomfort will come to the optometrist. Should the examiner merely

correct the existing visual defects and discharge the case, he will be surprised to frequently find them returning, complaining that, while they can see, etc., the symptoms still remain and so the work must be in some way faulty. This sort of thing can in most instances be forestalled by this careful recording of the patient's case history, for should we find, in discussing his past and present symptoms that he is afflicted with certain ailments which in no direct way can be associated with the science of occular refraction, it becomes our duty to first correct his refractive errors and then explain that the advice of some other specialist should be sought before the expected relief will be forthcoming.

Information regarding possible accidents or diseases which may have affected vision is next recorded. Material gathered at this point in the case history taking, will, in most cases, explain the existence of scars and opacities frequently found during the external ocular inspection or seen with the aid of the ophthalmoscope, and in recording this information, we at once know whether we are dealing with a visual infirmity of long standing, which the patient has become more or less adapted too, or to one of more recent acquisition which is perhaps the reason for his appearance at this time, or which may be still the cause of more or less of his discomfort.

4

The following two questions finish the case history with reference
1st set 8 to occurrences of the past. These questions are, first, *Age at start of*
9 *wearing optical appliances,* and second, *Number of years worn.* The answer to these questions, besides giving the examiner the direct information requested, will also give him the patient's mental attitude towards optical appliances, and also in general, on the eye work he has received in the past. In many cases it is advantageous for the refractionist to carefully weigh this mental attitude as persons who have gone through several unsuccessful refractions are frequently discouraged and the examiner must be, not only painstaking in his work, but also very optomistic, when possible, in later making his prognosis and attempt to get the patient in this same cheerful frame of mind, before he discharges the case.

4

The case history from this point on deals with conditions as they
2nd set are at the present time and the first logical question that arises is; *do*
6 1 *you notice any disturbance while viewing distant objects?* This is a common complaint of patients consulting optometrists and the second query put to the patient deals with an even more common type of re-
2 fractive error, that of a *visual disturbance at the near point.* Upon receiving an affirmative answer to either of the foregoing questions the examiner should seek to determine the *onset* of the trouble, *years, months, weeks or days ago,* and whether the onset was gradual or sudden. This is another important diagnostic detail and one that should be carefully inquired into. The progress of visual disturbances such as hyperopia

and myopia is very gradual, so gradual in fact that the patient is frequently unaware of the impairment until some particular visual need calls it to his attention. On the other hand, a sudden disturbance of vision is almost always pathological, usually due to some ocular disturbance such as glaucoma, although it may also be due to the effects of diseased tissue in other parts of the body, such as retinal degenration due to syphilis; a partial loss of vision due to paralysis, or a detachment of the retina due to an accident, or the result of a focal infection, etc. Thus the data received as to the type of defect and its onset is of diagnostic value and should be fully recorded.

3 *At What Distance Do You Do Your Work?* This query is of course closely allied with that of the patient's occupation, which we already know. It is advisable at this time to get this working distance only in a general way, as the data will be more fully and accurately recorded later on during the refraction. However, it is advantageous to know at this time the patient's working distance because it has direct bearing upon the next important question put to him, that *regarding his posture*
4 *while at work*. The effect of poor posture on school children has been the subject of more or less attention by physicians, and educators for years, yet the work done to improve the child's posture and to improve our knowledge of the ill effects of poor posture is still small in proportion to the amount of work which remains to be done. While the posture of children has received some consideration at the hands of specialists[5], the lack of attention on this subject with regard to adults is surprising, particularly regarding people employed in our large industrial organizations. True, the adult is no longer growing in stature but without a doubt, poor posture will undermine health just as surely in an adult as it will in a child and as optometrists it behooves us to give this subject the attention it merits. Whenever we find patients whose unconscious working posture is harmful we should from a hygenic standpoint, explain the harmful effects of sitting or standing in a somewhat slouched over position, outlining in a brief manner the possible and probable injury to the lungs, kidneys, liver and stomach as well as the eyes. As optometrists we are in no way going outside of our province in giving this advice as the effect of poor posture is in many cases the underlying cause of the visual defect we are trying to correct with optical appliances. For instance, a worker bending down over a bench with his head tilted on one side, his eyes within ten or twelve inches of his work naturally causes more fatigue to both the ciliary muscles and the recti muscles than he would were he working at a more normal distance of say sixteen inches and viewing his work from a more erect position. Thus this problem of posture becomes an optometric one as well as one for the worker in hygiene and the physician and it is well to keep it constantly in mind and to record data of interest regarding the patient's

working conditions. This naturally leads us to lighting conditions both at work and in the home, and data should be recorded with reference to type and intensity of illumination as well as to its seeming effect upon the eyes of the patient. When described as decidedly poor it would be well to secure the actual readings with a foot-candle meter[6], as many cases of ocular fatigue are traceable to poor and insufficient illumination.

5 *Do you become drowsy while doing close work?*

6 *Does type blur while reading?*

These questions are next put to the patient and need no explanation.

We now come to one of the most important questions that is to be

7 put to the patient; that with reference to *headaches*. On my record form I have divided this subject into four distinct parts: First, have you headaches? Second, the time the headaches occur? Third, the location of the pain. Fourth, type of headaches. The first part, if, answered in the affirmative is followed with the question as to the time that the headaches occur. This is quite important, as recurring headaches at certain times of the day are apt to be caused by pathological conditions and not by visual fatigue or strain. For example, a sharp pain over the eyes, from the time of rising in the morning until 10:30 A. M., recurring from day to day is one of the diagnostic signs of sinus trouble.

We now proceed to the location of headaches. This phase I have divided into five parts; they are as follows: Frontal pains, first; pains at the base of brain, second; pains at vertex or top of head, third; temporal pains, fourth; intraocular pains, fifth. To show the diagnostic importance of this subject I will in a few words attempt to explain the reasons for pains in these various portions of the head. Ocular disorders, of course, cause a large percentage of all headaches, but in certain cases where one finds little or no cause for ocular fatigue and where the patient complains of headaches in one or more of the above portions of the head, it is well to bear the following facts in mind. If a patient complains of frontal pains and has an apparent orthophoria with no ametropia, one may well suspect dyspepsia, constipation, liver or stomach trouble. If a similar patient complains of pains at base of brain one may well suspect nerve exhaustion or spinal irritation, or, a patient complaining of pains at top of head or vertex and being both emetropic and orthophoric, one may well suspect anaemia, a general rundown condition or genito-urinary troubles, or when a similar patient complains of temporal pains one should thoroughly search for the cause in a focal infection usually found in the oral cavity, nose, throat, or teeth[8]. Intraocular pains are, of course, generally caused by some type of ciliary disturbance or by an ocular pathology.

Now as to types of headaches, there are four general types and I have classified them as follows:

Dull headaches, first; constrictive headaches, second; pulsating headaches, third; and pressing or hot burning headaches, fourth. This subject of types of headaches is, of course, closely allied with the subject, of location of headaches and the information the examiner gets on one, generally helps explain the answer to the other.

The dull headache is generally, though not always a frontal headache, and may be attributed when not to visual fatigue to the same causes that generally cause frontal pains, that is, stomach disorders, liver trouble, constipation and dyspepsia. The constrictive or squeezing type of headache, when not due to visual defect may be due to a general rundown condition and a visual rest should be suggested along with a thorough examination by the family physician. The pulsating headache or a throbbing pain in the head can usually be traced to disorders in the circulatory system, while the hot burning or pressing pains are attributed, as a rule, to either ocular disturbances, focal infections or anaemia. Thus it is readily seen that the patient can, in a few words give the examiner much information regarding his or her physical condition as they describe their headaches, and as headaches are either symptoms of a visual defect or symptoms of some other disorder, it is well to record this information very carefully.

The following question is one which is closely allied with that of headaches; that of *nausea* or *dizziness,* whether suffered at home or while riding on trains or cars. This is a rather frequent complaint and many patients, have had much relief from these distressing symptoms by a properly fitted correction although Wiseman[9] lists some ten other causes of this symptom.

The patient is now asked the following seven questions, the need of which I am sure will be apparent:

Are you subject to granular lids?
Are you subject to an inflamed conjunctiva?
Are you subject to epiphoria?
Are you subject to diplopia?
Are you subject to photophobia?
Are you subject to muscae volitantes?
Are you subject to hordeolums?

The diagnostic significance of these inquiries is as follows: Usually granular lids, hordeolums and sometimes a congested conjunctiva are symptoms of myopia; epiphoria, when not due to a stoppage of the tear duct, is frequently a symptom of high degree of hyperopia. Diplopia is either a symptom of a muscular imbalance or a pathological disturbance of the visual field. Photophobia is a symptom of most of the inflammatory diseases of the eye while muscae volitantes, although normal, may also be pathologic. Many myopics see these specs because of the abnormal length of the eye-ball as do some syphilitic cases and when these are

complained of a very searching opthalmoscopic examination should be made. Thus I repeat, the answers to these seven questions are of real diagnostic value, making it essential that these be put to every patient.

At this point I will quote a paragraph from Woll[10].

"Making a record which tells us everything that it is possible to find out about the eyes and nothing about the general condition of a patient is really considering the eye as something separate and apart from the rest of the body. The eye is a part of the body. The eye tissues cannot be any healthier than the tissues of the rest of the body. If a body through improper living, disease, or ailment, becomes debilitated, eyesight cannot be one hundred percent efficient in that body. The converse we know is also true. Uncorrected or improperly corrected eyesight will surely deplete the working efficiency of the body. These are facts, and they more than prove that eye efficiency is complemental and supplemental, not merely supplemental only. It is suggested, therefore, that the case seems proved and that in the interest of thoroughness and accuracy there can be no objection to the including of a record of health status and health habits."

The writer for years has agreed with Woll in this and has insisted on answers to the following questions:

Condition of ears?
Condition of nose?
Condition of throat?
Condition of teeth?
Subject to sinus-trouble?
Subject to tonsilitis?
Subject to catarrh?

A report on the conditions of these organs will prove helpful in making the diagnosis as frequently patients are apt to believe that the eyes are the cause of their many ailments when in reality in their case ocular disorders may have little or no part in causing them, and if some defect in other organs is unearthed by the refractionist in his questioning of the patient he will frequently refer the patient elsewhere for further treatment, whereas, had no questions been asked he may have been tempted to say, "use this ocular prescription and it will relieve your symptoms," then, later, because the optical appliances did little or no good, the patient returns complaining or is apt to go elsewhere for attention.

To complete the History regarding the patient's physical condition, I have had inserted in my History Chart the following questions:

Condition of stomach?
Condition of nerves?

Condition of vital organs, and when female and married, if pregnant?

General condition of health, and finally, under care of Dr..........., for..................?

This concludes the history of the patient regarding his vision, ocular pathological symptoms and general health, and we next turn our attention to the personal hygienic habits of the patient. In this connection, I shall again quote a few words from Woll, "Whether people know how to live correctly or whether they do not, all are in need of some kind of health advice; all at some time have eyesight troubles. All these troubles may not be entirely due to eye defects. Sooner or later, however, the aid of the eyesight specialist is sought, and then the optometrist has the opportunity to give some simple straightforward health advice besides prescribing correcting lenses. Giving that advice need in no way carry him outside his chosen sphere or usefulness, but will, instead, increase his value to his patients, to his profession and to his country. Only too often are optometrists accused of being too willing to prescribe and sell glasses. It would be a startling revelation, at least to some patients, if they were told that they need to correct their habits rather than wear glasses to correct their eye defects. This, of course, does not mean that all slight errors of ocular refraction with their reflexes may be corrected by living up to the laws of hygiene. It does mean, however, that correcting bad habits will often give relief or end in giving relief when it is apparent that a low error of ocular refraction should not cause all the reflexes that are shown."

It must be seen, therefore, that questioning the patient with reference to his personal habits or personal hygiene will in many instances enable the optometrist to give greater and better service, and with this in mind the following questions are now brought forward: first, to use in either moderation or excess of tea, coffee, tobacco, alcohol and drugs. Second, with reference to personal habits regarding eating, sleeping, bathing, exercising and excreting.

These questions cover the ground of personal hygiene quite thoroughly and the use of them will enable the examiner to, at times, give patients advice which will prove invaluable. I will here cite a case from my own practice. Mr. R. O. A., age fifty-five, occupation, floor walker in department store[11]. Visual disturbances corrected with plus 0.75 D. Sph., addition, plus 2.25 D. Sph., O. U. this give $^{20}/_{20}$ vision, June, 1921. He experienced complete satisfaction until November. I must say at this point that the questions referring to personal hygiene were not at that time used by the writer, so were not asked the patient at the time of refraction in June. In November, 1921, he began to have difficulty seeing distant objects clearly and also was subject to, as he termed it, a cloud over his eyes, when he tried to do close work. He came to me and I again made the refraction; ophthalmoscopic diagnosis normal, syphmo-

manometric findings, technique-osculatory, systolic 140, diastolic 98, in other words, normal for his age. Could not improve his lenses, although vision was at a distance 20/30 O. U. and he, with difficulty, could read numbers in phone book. I then asked him if he had visited his family physician and he had, but his physician had told him it must be a visual defect and had referred him back to me. I then began to question him very closely. I told him to tell me everything he usually did in an average day, from the time of getting up to going to bed. What he had been eating and drinking and with what results, etc. It gradually developed that he was an inveterate coffee drinker, consuming three cups of coffee for breakfast, two or more at lunch, generally one or two about three P. M. (he was stationed near the house restaurant) and two or three more at dinner and always one before going to bed. He had done so for years and thought that a little coffee couldn't hurt anybody—furthermore couldn't get along without it, etc. This made ten to twelve cups of coffee per day. I suggested that he cut this down to two cups per day, breakfast, one cup and dinner, one cup. This was impossible, so he said and he would have to try elsewhere to get relief. Started taking chiropractic treatments and had about ten adjustments with no apparent effect. He then was somewhat worse, so bad, in fact, that he was given two weeks off in which to take a complete rest. During this rest, in which he stayed home and had two fainting spells, he again had the family physician, who prescribed some stimulant. This was taken and although he felt stronger, he still could not see. He came into the office December 18th or 19th, wanting to know if there wasn't something I could do, and as he was quite worried, now, as the prospect of losing his position was very distasteful, I again brought up the subject of coffee. He decided to try it for two weeks. On January 12th, 1922, he again called at the office. He hadn't tasted coffee for ten days and since December 19th had never taken more than two cups any one day. His vision was now 20/20 O. D., or O. S., and he could read smallest type on card, felt fine and looked better than I have ever seen him.

This, you may say, is an extreme case. It probably is. I have never had another just like it, but I believe it is worth the energy required to ask these questions to many, many patients if the information secured from one enables me to help him.

To return now to the final step in completing our case history, that of observations. This, of course, is done after the refraction and I would suggest it being done the minute the patient leaves the office as one's impressions are clearest at this time. Record is made of the following data: Is the patient short or tall, emaciated, medium or obese, a blond or brunette, nervous, normal or phlegmatic, weak and tired or strong and active, breath, clean or foul, condition of oral cavity, condition of skin and finally, apparent disposition. The reason being, that: anything

worth doing at all is worth doing well and so it is with records. Six months from now I may be looking through my record books for the prescription of a certain type of case; this information will greatly assist me in visualizing the patient and bringing back to mind some of the minor details of the case not written in the record.

Previous Prescription

In the event that new work is being started on a patient who has had work done before by the same refractionist, the previous records should be taken from the files and brought in by the secretary immediately after the new history has been taken. At this time a careful comparison should be made of the two or more histories, as well as of the findings of the previous refractions, regardless of their number. This is advisable as it prepares the examiner for what is to come and permits him to note at once, any material changes which have taken place.

Record of Present Correction

Should the examiner be making his first refraction of a patient already using optical appliances, a record of the formula of these should be made at the close of the history taking. This should be done for the same reason as previously mentioned, *i. e.* that the possession of this formula throws light on the patient's previous visual condition, a thing of decided advantage, and one not to be lightly discarded. The writer has heard examiners boast that they never have neutralized a lens prescribed by some other refractionist, and he firmly believes this attitude to be a mistake as the patient has come to him for the fullest and most complete service available and he feels that every possible move should be made towards this end. The formula prescribed by some other refractionist, while by no means telling a complete story, nevertheless does give a specific clue as to the previous visual disorders as found by this refractionist. After these lenses have been neutralized a record is made of the formula along with the time and manner in which it has been used.

Visual Acuity Uncorrected

There have been four outstanding developments made within the last decade with reference to the matter of recording visual acuity. In the past examiners were obliged to use block characters drawn to subtend the five minute angle, these characters being printed on cards in both English, German, Jewish and other languages, as well as being made up entirely in figures; the broken ring test for illiterats; the letter E in various positions for the same purpose and the kindergarten characters

drawn to size as best possible for the acuity check for children. These cards served their purpose well, but in each instance something was lacking and as in other sciences, improvement was sure to come.

The first development came with the origin of the Ives screen for recording a patient's acuity of vision. This screen is so devised that as soon as it is in focus for a patient the gratings become clear, standing out as white square of different sizes, while as long as they are out of focus the gratings are not visible as such, they appearing only as a neutral blur.

Next, Ryer[12], working along different lines suggested that the usual block characters be drawn into the twenty-five small one minute angles squares subtending the larger five minute angle square of the letter, all of the lines of the small squares showing, the advantage being that unless the character was in perfect focus the crossed lines made it so indistinct that guessing was out of the question. He also suggested making the characters spectrum red in color on a flat white rather than black as formerly used, he claiming that this arrangement made it possible to prescribe more plus and less minus than the charts made up in black characters on a white background. In this connection, Ferres and Rand[13] suggest that the illumination of the test characters should be made as nearly as possible the same as that usually employed in the vocation of the patient. This would usually not exceed fifteen foot candles.

Third, Wiseman[14], in a research with the Tri-City Optometric Society devised a test chart in which the letters for each distance were placed in a staggered group, rather than in rows and in which the letters were accurately made to size with regard to their legibility as well as made to subtend the five minute angle, thus a letter such as a B which is rather difficult to distinguish, would be larger in size than one inch as an O which, because of its symmetrical outline is camparatively easy to distinguish, both letters however being in the same group.

Clason, studying this problem from yet another angle suggested that instead of printed charts for taking the acuity of vision, it would be more satisfactory to have the usual block character on glass slides and by refocusing a projection device change the size of the image of the character as projected on a screen at some known distance. Thus Clason's Visual Acuity Meter was devised. The size of the projected character is increased until decernable by the patient and at the same time a scale is read by the examiner, which gives the acuity of vision, in percentage.

These newer developments in apparatus for taking the acuity of vision all point to greater accuracy and to a newer system of recording these findings. Instead of the Snellen Fractional Notation, the Percent-

age System[15] is steadily gaining ground and with it the kindred notation in Visual Efficiency[16,17], which the writer believes will, in time, entirely supplant the other systems, at least in industrial work and in public surveys.

The need for making this uncorrected visual acuity test at this point in a routine refraction is, I believe, obvious, as it affords the examiner information of importance. For instance, a patient who has normal vision cannot be myopic nor have much astigmia, while in one whose vision is materially subnormal the examiner must be more careful in searching for symptoms of pathology or for ocular reflex signs of the effects of focal infections.

The technic used in making an uncorrected visual acuity test is as follows: A trial frame is placed on the patient and one eye is occluded with an opaque disc. The patient is next instructed to read or view whatever visual fixation device is used, indicating just what is seen. A record is made of the point at which the patient no longer has acute vision. The same procedure is then followed for the other eye, the first being covered with the disc.

For patients whose vision is extremely poor one can record the absence or presence of Visual Perception by means of the Ivory Ball Test Set.

In making this test the examiner bandages one eye and then tosses out Ivory Balls upon the floor, these balls made in different sizes and rolled in various directions, the patient trying to follow the movement of the small rolling object on the floor as it receeds from him. These sets of Ivory Balls are advantageous in cases of very high myopia and also in amblyopia. When vision is so poor as to make this impossible, the finger test should be employed. This is accomplished by having the patient monocularly count the examiners fingers as he holds them before the patient, at some given distance. Findings are recorded in some detail in these latter cases, particularly in those of cases of amblyopia, whose vision the examiner is to improve with treatments, as it is well to know just how poor the acuity of vision was at the time of the initial examination.

In these cases of extreme subnormal vision of an eye, after a record has been made of whatever uncorrected acuity is present, the writer usually resorts to the use of the pin-hole disc in an effort to improve vision by cutting off the abberation of the peripheral rays. This is frequently effective and indicates that vision in this case can be improved with lenses. In the past it has been the custom unfortunately, to pause in our efforts to improve vision in an eye, if the use of the pin-hole disc failed and this practice, we are fast finding out was a mistake inasmuch as many cases of amblyopia ex anopsia have been successfully treated, the vision improving from near light and dark perception to a visual efficiency of from fifty to eighty percent[18]. Of course only a small number of cases having such low visual powers are cases of amblyopia

ex anopsia, yet it behooves the optometrist to carefully carry his examination of this type of case as far as possible before discharging the case without applying some prophylactic measures[19] to restore its usefulness.

The Cover Test

While the cover test is not in every case a reliable guide, it is nevertheless of sufficient value to warrant a place in the routine refraction at this point. The test is simply made by having the patient fix binocularly a distant light placed at twenty feet. While so doing the examiner covers one eye with a small card, and a moment later quickly withdraws the card, at the same time observing the position and movement of the eye which has just been uncovered. After considerable experience with this test, the writer believes the normal condition will be found as follows: the covered eye will be noticed to be in a slightly divergent position and will upon the removal of the card turn in slightly to binocularly fix the light in conjunction with the uncovered eye. Various authorities do not agree with the writer in his belief on this however, Thorington[20], for instance claiming this indicates a weakness of the internal recti.

The Uncorrected Phoria Test

The cover test is followed immediately by the uncorrected phoria test. Fixing the same light, the writer using for this purpose a Greek Cross, a maddox rod is placed before the patient's right eye in such a position that both a cross and a vertical streak of light are seen. The Stevens phorometer is then employed to measure the deviation, if any, which is present, the findings being duly recorded. The uncorrected phoria test is then repeated at thirty-three centimeters. The diagnostic advantage gained by making this phoria test at this time is two fold: First, it enables the examiner to know, before the refractive tests are made, just the type of case he is dealing with, the esophoric case indicating a patient with a high body tonicity or nervous reserve, the exophoric patient one with a low body tonicity or nervous reserve[21], and second the taking of the uncorrected phoria findings at this time eliminates the dangers of prescribing a correction in such a manner as to necessarily increase the convergence-accommodative effort, a thing to be avoided at all times[22], as these uncorrected findings can later be compared with the phoria findings made with the full correction in place.

The Version Test

It is well at this point in the routine refraction to make a test of the versions. This is simply done, the examiner standing directly before the patient. Should the examiner wish to check the versions of the

patient's right eye he covers the patient's left eye with the examiner's left hand, at the same time holding some small object, a pen for instance, in his right hand, midway between the patient and himself. The patient is now instructed to watch this object which is now moved in a large circle before the right eye of the patient, the examiner at the same time observing the movements of the patient's right eye. The test is then reversed for the patient's left eye. A version test of this character will at once reveal any paralysis or partial paralysis of any one of the recti muscles.

Special Subject

External Ocular Inspection

In starting this inspection the first thing one notes is the general appearance of the eyes. Are they very far apart; are they close together; or, are they horizontally on plane, one with another, or is one higher than the other? Or is any other type of facial or ocular deformity present? If so, these data should be recorded. Next we turn to the orbits themselves, and note any manifest abnormalities there. This concludes the general examination of the eye and can readily be done by merely observing the patient while the case history is being taken. We next turn our attention to a more detailed examination of the various parts of the ocular region as seen externally. The writer has found it advisable in making this portion of the examination, to tilt the patient back, at an angle of from thirty to forty-five degrees in an ophthalmic chair. It is of course necessary to have a comfortable head rest and the patient should be fully relaxed, facing a good light. The writer uses a frosted one-hundred watt daylight lamp on a sliding bracket in addition to a movable spotlight used for focal illumination. It would seem best to start one's detailed examination of the external structures of the eye with a careful inspection of the eyeball itself. Is it deepseated, normal in position, or protruding? If deepseated, a condition called enophthalmos, it probably is due to advanced years, or to the extreme emaciated condition of the patient but may also be the result of a trauma[23]. If protruding, a condition called exophthalmos, one should have the patient examined for tumors and other afflictions of the orbital region[24]. This protrusion also is one of the diagnostic points or signs of a form of goitre[25] and also results from both injuries and inflammations in the eye and orbit and it is at times caused by a thrombosis in the sinus cavities. Any marked departure from normal calls for a searching examination of the orbit by one specializing in this work.

Finding the eyeballs normal in position we now examine them for size and lack of symmetry. The normal eyeball of a child is from eighteen mm to twenty-one mm in diameter, while that of an adult is from twenty-one mm to twenty-seven mm[26].

We next take the tension of the eyeball. This can be done by means of palaption. We direct the patient to look down and then placing our index finger on the upper lid palpate the sclera above the cornea, pressing downward. The tension is taken by estimating the degree of tension of the eye being examined with that of a normal eye. The tension of each eye is taken this way and recorded, Tn, when the tension is normal, Tn plus, indicating increased tension, Tn minus, dimished tension. This is a very important phase of the external inspection and should never be omitted. The taking of the ocular tension is important as it is one of the diagnostic tests for glaucoma, an increase in tension indicating that condition[27], and the palpation also gives the examiner information regarding the presence or absence of sensitiveness in the ciliary region. Normally this palpation should cause the patient no inconvenience.

We next proceed to examine the lids. Naturally the first thing noted is the size of the palpebral fissure. Next the ability to move the lids, looking for a blepharospasm or a ptosis of the lids. Next for an entropion or an ectropion and further examining the lid edges for swellings, crusted areas or ulcerations and the lashes for number and signs of trichiasis. The condition and position of the puncta are noted also at this time.

The skin covering the anterior portion of the lids is examined. This is done by means of version of the upper and lower lids and the color, surface and transparency of the conjunctiva is noted. Here one looks for ulceration, scars, granulation and thickening, noting any variations from normal. Here one will frequently find ocular infection, and as refractionists we should never prescribe a correction until the infected area is removed. Those of us living in states where trachoma is at all prevalent must be very careful in checking cases for this highly infectious disease.

The anterior portion of the eye is next to be examined. This can best be done by means of focal illumination or with the aid of the slitlamp. The latter method is of course preferred, the new hand instrument being splendid for this purpose, permitting the examiner to easily see the layers of the cornea, the aqueous, the iris, the lens and at times a portion of the ciliary body[28]. This instrument not being available one can do nicely by means of focal illumination. Here one needs a strong steady source of illumination and a double convex lens. The writer, when examining by means of focal illumination has found a 13D double convex sphere, about two inches in diameter, of great value. The rays of light are focused on the area to be examined with this lens while the examiner views the areas through a strong binocular magnifier. In this way small deformities which would escape one's notice under ordinary means of observation can be detected.

The bulbar conjunctiva and the cornea are first examined. Being transparent we look for traces of color, thickening, opacaties, scars, inflammation and ulcers. Here is a fruitful field for careful inspection. Many cases coming to us as refractionists do so because of small corneal ulcers which, unless carefully watched for, may pass unnoticed. These small ulcers are usually caused by a focal infection or various bacillus[29] and as soon as such ulcers are noted it becomes the examiner's duty to have the patient's teeth, tonsils and sinus cavities examined as well as to refer him to his family physician. In addition to having the patient examined to find the cause of the ulcers, they themselves must be removed either by surgical methods or by medicinal means, and this must be done at once, to eliminate the dangers of leaving permanent scars which would naturally interfere with the patient's vision.

The size and form of the cornea is also noted and care should be taken to get corneal reflexes with a placidos disc should any corneal irregularity be suspected.

Leaving the cornea we next turn our attention to the sclera and the portion of the conjunctiva covering the sclera. Here the color of the sclera should be bluish white and we note any variations from the normal color. We also look for signs of a staphyloma of the sclera and for episcleritis or scleritis. We carefully note the presence or absence of a pterygium, inasmuch as this common conjunctival growth may be productive of much corneal irregularity, which might puzzle the examiner later on if the cause is not discovered at this time.

The anterior chamber containing the aqueous is next examined for depth and clearness of contents. Here, too, we, as refractionists, must be very careful, as two serious ocular diseases can frequently be detected at this point. The first is iritis, an inflammation of the iris which in nearly every case clouds the anterior chamber and gives it the appearance of great depth[30]. The other disease, frequently discernible at this point in the examination, is glaucoma. With the increased intra-ocular tension the anterior chamber will appear very shallow[31].

The lens is next examined. Its presence or absence is noted, along with its position and color.

Following this the iris is examined. Its position is noted along with any malformations and adhesions. It is important that the iris hang free in the anterior chamber, inasmuch as any attachment will naturally hinder the sphincter pupillae and dilator pupillae muscles of the iris, preventing this sensitive organ from functioning as it should. The iris is next examined for signs of iritis. When this diseased condition is present the iris appears full and sometimes swollen. The usual markings are missing and the structure lacks its usual lustre. The pupil in iritis is contracted and very sluggish in action and will frequently be found to be irregular in shape, and apparently "off center." Iritis in

common with corneal ulcers, frequently has its origin in a foci of infection, although it may also be due to syphilitic, rheumatic or diabetic conditions[32], and the same care should be exercised in handling this type of case as in one of corneal ulcer or glaucoma.

The pupil is next inspected. Its position, shape and general size is noted. The pupil should be circular in shape with a regular outline. Any variation from this normal demands the most careful and painstaking recheck for all types of pathologic conditions.

The final step in the external ocular inspection is made in taking the pupillary reactions. This is very important and should be done without fail in every case, as in many respects the examiner will receive from these simple tests information of real value in making his diagnosis. The first test is the pupillary reaction to light. This test is simply made by exposing the eye to the rays of a moderately strong light. Normally the pupil will contract. However, in cases of iritis and in the first stages of glaucoma the reaction will be very sluggish. In a glaucomatous attack there will be no reaction at all, to light. The second test is the pupillary reaction test to accommodation and convergence. This test like the other is easily made by merely holding some small object from six to ten inches before the patient having him fix upon it. Normally the pupils will be seen to contract. Under certain conditions the pupil will respond to accommodation but not to light. This is called an Argyle-Robertson pupil[33] and is caused by either a mydriatic having been previously instilled or by the patient being afflicted with locomotor-ataxia.

The pupillary reflexes are a splendid help in diagnosing nervous disorders and brain lesions and marked changes in size and equality of the pupils should be carefully watched.

These few simple check tests comprising the external ocular inspection can easily be made. They take but a few moments to do and give so much of real value in the way of differentiating the normal eye, free from pathology from the one suffering from some form of pathology, that they should never be omitted.

Ophthalmoscopic Diagnosis

The most striking development of the last decade in the matter of clinical aids to diagnosis is the binocular ophthalmoscope of Gullstrand. In this instrument, says Duke-Elder[34] the light from a linear intra filament, after passing through a condensing system, is reflected by a plate glass through one-half of the dilated pupil. Through the unilluminated half of the pupil the fundus is viewed by means of binocular telescope. Since the unilluminated portion of the pupil is utilized, all corneal reflexes are eliminated. Owing to the telescopic arrangement, refractive errors introduce no disturbing variations, so that the fundus of

a high myope can be viewed with perfect ease, and a stereoscopic view is obtained whose peculiar advantage is the accurate appreciation of different levels in the fundus when tumors, exudations and haemorrhages, and swellings of the disc are present. By replacing the usual binocular telescope by a monocular eyepiece and a periscope, two observers may view the same fundus at the same time—the ideal for a teaching clinic. Magnifications of from ten to forty diameters are available; that is, up to the limit imposed by the possibilities of fixation.

Despite the volumes which have been written within the past few years on the newer developments of ocular diagnosis with the large binocular Gullstrand ophthalmoscope the writer nevertheless believes as does Wurdemann[35] that this instrument is not absolutely necessary for skillful work. A good hand ophthalmoscope with a red-free attachment, preferably self illuminated with a rheostat will, when properly used enable any optometric examiner to differenciate between the normal and abnormal fundus, betwen a clear and cloudy media and also enable him to examine the crystaline lens in sufficient detail for proper diagnostic work.

The writer is partial to the direct method of ophthalmoscopy, he believing the technic more sure and the application made with greater ease than by the indirect method. The technic of the direct method is as follows: Have the patient fix an object across the room that lies on a level with his eyes and a little to the nasal side of the eye to be examined. It is well to put two small objects on the wall[36] for the patient to look at; each object on a level with the patient's eye, and one to the right and the other to the left of the median line. This is done to place the patient's disc in such a position that the examiner can see it with the ophthalmoscope directly from the front.

To view the patient's right disc the examiner seats himself slightly to the right of the patient with the ophthalmoscope before his own right eye. The patient is then directed to look at the object on the wall that lies slightly to his left. The examiner now throws the light into the patient's pupil at a distance of six or eight inches and gradually approaches his eye, moving his head slightly until the disc is visible. At first it will appear as a blurred white area. Holding this area in view and moving still further forward, until one is within an inch or so from the patient's cornea, the examiner will find in the normal eye the disc in focus, or if it is not then in focus the examiner can turn in lenses, either plus or minus until the fundus becomes clear. Retinal vessels can be traced away from the disc and the entire fundus examined by having the patient look slightly up, down, in, and out. To see the macular area, the patient must look straight in the hole of the mirror on the ophthalmoscope, or the examiner can have the patient fix some distant object directly in front, while he approaches the eye slightly

from the temporal side, first finding the disc and later moving outward about a distance equal to the diameters of one and one-half discs. This procedure is naturally reversed for the other eye.

In case of high myopia the patient can be instructed to keep his correction in place while the ophthalmoscopic examination is made, this aiding the examiner in getting a clear view of the fundus. To eliminate the reflected glare from the surface of the lens it may be necessary to slightly tilt the lenses in the vertical meridian.

At this point it will be advisable to mention ophthalmoscopy with red-free light. Normally the retina is practically transparent and in viewing the fundus ordinary light is permitted to pass through on to the choroid. Mayou and Voight after some experimental work discovered however that the shorter waves of the spectrum do not have the penetrating power of the longer red rays, and consequently when used alone with the red rays excluded, the retina, instead of allowing them to pass through, absorbs some of the rays, but reflects a greater part, thus becoming visible[37]. The advantage of using the short waved red-free light in ophthalmoscopy is, that much greater detail is secured than with ordinary light, the vessels particularly becoming sharply outlined against the bright background, the examiner also finding the nerve fibers standing forth as distinct white lines.

In viewing a patient's fundus the shape, color and type of disc is noted. Whether or not the cup is visible, along with its color and depth. The distinctiveness of the choroidal ring is next looked for with a possible showing of the scleral ring. The number and course of the bloodvessels is then noted, followed by an examination of the macular area, noting particularly its color. The writer has found it advisable to provide on his record chart a space for a fundus drawing and suggests the use of the following printed form, one for both the right and left fundus, this form being easily filled out, and making a splendid permanent record.

FUNDUS NOTATION. Right Eye.

The disc is $\left\{\begin{array}{l}\text{round}\\ \text{oval}\\ \text{elliptical}\end{array}\right\}$ in shape, $\left\{\begin{array}{l}\text{pale}\\ \text{medium}\\ \text{dark}\end{array}\right\}$ rose reddish in color, with a $\left\{\begin{array}{l}\text{broad}\\ \text{medium}\\ \text{narrow}\end{array}\right\}$ $\left\{\begin{array}{l}\text{clearly}\\ \text{average}\\ \text{poorly}\end{array}\right\}$ defined edge, the tendency being to merge off towards the $\left\{\begin{array}{l}\text{nasal}\\ \text{temporal}\end{array}\right\}$ side. The cup is $\left\{\begin{array}{l}\text{small}\\ \text{moderate}\\ \text{large}\end{array}\right\}$, it being $\left\{\begin{array}{l}\text{easy}\\ \text{difficult}\end{array}\right\}$ to see, and is $\left\{\begin{array}{l}\text{very deep}\\ \text{average}\\ \text{shallow}\end{array}\right\}$. The choroidal ring shows

$\left\{\begin{matrix}\text{very strongly}\\ \text{clearly}\\ \text{faintly}\end{matrix}\right\}$ on the $\left\{\begin{matrix}\text{nasal}\\ \text{temporal}\end{matrix}\right\}$ side, with the scleral ring showing at the........................ The vessels are approximately........... in number, their course being.., and their pulsation quite $\left\{\begin{matrix}\text{moderate}\\ \text{marked}\end{matrix}\right\}$. The macular region is rather $\left\{\begin{matrix}\text{easy}\\ \text{difficult}\end{matrix}\right\}$ to discern, the general color being a $\left\{\begin{matrix}\text{pale}\\ \text{medium}\\ \text{dark}\end{matrix}\right\}$ reddish, with $\left\{\begin{matrix}\text{one}\\ \text{no}\end{matrix}\right\}$ $\left\{\begin{matrix}\text{small}\\ \text{medium}\\ \text{large}\end{matrix}\right\}$, bright foveal dot being visible. The general fundus color is of the $\left\{\begin{matrix}\text{feeble}\\ \text{moderate}\\ \text{pronounced}\end{matrix}\right\}$ $\left\{\begin{matrix}\text{blonde}\\ \text{brunette}\end{matrix}\right\}$ type. The outstanding features of this fundus being as follows..................and have been sketched above.

While the arrangement of the preceding fundus chart is original with the author, he at this time wishes to credit the idea itself for this type of chart to Kress[38] who in 1923, published a splendid treatise on this subject of recording ophthalmic findings, and who arranged much of his material in somewhat this way. A few of the abnormal fundus conditions occasionally seen by the examiner are retinitis pigmentosa, choroiditis, retinal detachment, neuroretinitis and the condition of the fundus with particular reference to the disc as seen in cases of glaucoma. There are many other fundus abnormalities but those just mentioned comprise the majority most frequently seen. Let it suffice to say that patients suffering from abnormalities of this kind require special treatment.

Sphygmomanometry

The patient's blood-pressure is taken immediately following the ophthalmoscopic examination. Syphilis, kidney disorders, tuberculosis, heart disease, arteriosclerosis, diabetes, craneal tumors, anemia, goitre and uremia all frequently cause abnormal blood-pressure and also cause symptoms similar in many instances to those caused by ocular disorders. This being true it is necessary for the best interest of the patient as well as to protect the examiner that the patient's blood-pressure be taken at this time in a rountine refraction. Patients suffering from the symptom of an abnormally high or an abnormally low blood-pressure, after having their ocular defects corrected are referred to some other specialist for complete physical examination.

The equipment necessary to perform this portion of a routine refraction is a sphygmomanometer, either of the aneroid or mercury type, and a stethoscope.

While there are several forms of procedure the writer believes the Auscultatory method the preferable, its technic being as follows: The arm-band is applied to the left arm at the level of the heart. Care must be taken that an inch or so of bare arm is exposed between the elbow and the lower end of the bag. The bag is inflated and the bell of the stethoscope is applied to the bare space just mentioned, care being taken to place the bell over the artery. As the pressure of the bag is raised a thumping sound will be noted. The inflation of the bag continues to a point ten to twenty mm, above the level at which this sound disappears. The pressure is then slowly released until a thump is heard with the stethoscope. The point on the dial of the instrument at which the arrow is pointing when the thump is heard is the systolic pressure, the most important reading from an ocular diagnostic standpoint. Keeping the stethoscope in place the pressure in the bag is further slowly reduced, the examiner now hearing a low murmur, which continues until transformed into a clear snapping thump which lasts but for a moment and then changes into a dull thumping, the latter lasting for from three to five seconds at the end of which time all sounds disappear. The point where the second snapping sound becomes transformed into a dull thump represents the diastolic pressure. The pulse pressure is the difference between the two.

Normal systolic pressures average in young adults from one hundred and five mm., to one hundred and fifty mm., the diastolic pressure being from thirty to fifty mm., below the systolic. Any material variation from these findings necessitate advising the patient to have a physical examination as soon as his or her ocular work has been completed, or if possible at the same time that it is being done.

Optometrists wishing to secure more detailed information as to the diagnostic value of sphygmomanometry or to its technic in an ocular examination, are referred to the splendid researches of Wiseman[39].

Transillumination

While the writer is fully aware that many authorities no longer place emphasis on the findings of transillumination, prefering the use of the X-ray where possible, he fully realizing the weaknesses of transillumination, does nevertheless choose, to place this form of diagnostic technic in his schedule of a routine refraction, at this point.

The reasons for so doing are as follows: Focal infections in the maxillary antrum or nasal accessory sinuses are at times the cause of reflex ocular disorders which naturally will not be corrected until the

focus of infection itself is eliminated. Transillumination, while failing in some cases, gives the examiner a sufficient shadow-like clue as to the cause of the disorder to enable him to advise and insist on the further use of the X-ray, for additional diagnosis.

Transillumination is also used in connection with the eye although a different type of instrument is here to be preferred. The writer has used the transilluminator of Wurdemann for ocular diagnostic work for some years with splendid success. The instrument is smaller and different in shape than most transilluminators of its kind and is only used for searching the anterior portion of the globe of the eye for tumors or foreign bodies as well as to examine the size of opacaties of the lens although Fox[40] claims that at times even a detachment of the retina can be faintly seen.

The technic of examining the lens for opacaties the writer has found of value in cases where the central portion of the crystaline lens is effected. Having the patient look up, the transilluminator is placed firmly against the lower lid, the rays so directed that they pass through the sclera below the cornea. The interior of the eye is in this way fully illuminated and the lenticular opacaties will be found to stand forth as either grayish or black patches in an otherwise transparent lens, enabling the examiner to more easily note their size and shape, than by means of either focal illumination or ophthalmoscopy.

Tests for Color Blindness

Modern science today has before it four principle theories of color vision. Each of these differs from the others in some important phase, none of these being entirely satisfactory under all conditions.

The first of these theories is the Young-Helmholtz theory[41]. This theory assumes that the terminal fibrils of the retina are arranged in three distinct sets for the reception of the three primary colors, red, green, and violet. These groups correspond to the three colors and acting simultaneously induce the sensation of white. Red light entering the eye effects to the greatest extent the group of filaments known as the red sensitive element, but also effects the others to a slight degree. In a like manner green and violet are perceived by their corresponding sensitive elements. The absence or imperfect development of the retinal filaments set aside for one of these primary colors will cause this color to be seen as if composed of the two remaining colors, thus giving rise to color blindness corresponding to the deficient elements.

The second of these is the Hering theory[42] of color sense. This theory assumes the existance of three separate visual substances in the retina. Each of these substances is decomposed by the action of light and

is renewed when the eye is permitted to rest in the dark. Both the decomposition and the renewal of the visual substances result in the production of ocular sensation.

The Edridge-Green theory[43] of Color Sense, is the third. This theory may be defined as follows: The cones of the retina are insensitive to light, but are sensitive to certain chemical changes set up in the visual purple. The latter substance is liberated from the rods when the light falls upon the retina, is then diffused over the fovea centralis and other parts of the retina, the impulse being then transmitted through the optic-nerve fibers to the brain. According to this theory, says Fox[44], we may look to the impulse itself for the physiological basis of color.

The fourth of these theories is the Ladd-Franklin theory[45]. This theory assumes that a single light-sensitive substance exists in the retina. This substance exists in three stages of differentiation. In the first stage its decompisition leads to various graduations of achromatic luminosity ranging from black to white. The second stage of change of substance is divided into two parts, one of which is decomposed by yellow light and the other by blue light, the products of these decompositions acting upon the optic nerve to produce yellow or blue sensations. The equal decomposition of both these at the same time would result in the sensation of gray. The third stage of change of substance consists of the breaking up of the yellow-sensitive component into red and green-sensitive constituents respectively.

These theories show briefly the complexity of the visual apparatus which turns radiant energy into the various light and color sensations with which we all are familiar. It is therefore obvious, in an eye which is anatomically abnormal or which is suffering from some form of fatigue or pathology, that these delicate mechanisms which function to produce color vision may become affected. When they do we have a condition known as color-blindness.

Patients suffering from this defect may be divided into two groups; first, those patients whose color sense is entirely lacking and second, those who are partially color-blind. Total color-blindness is very rare but from three to four percent of all males are partially color-blind and from one-half to three-fourths of one percent of all females are partially color-blind. In these cases, generally only one, though sometimes two, of the color sensations are wanting.

Color-blindness itself is logically divided into two forms, the Congenital and the Acquired. The Congenital being the most common, though the possible presence of the Acquired form makes the taking and recording of the patient's color vision necessary as a diagnostic test for pathology or reflex toxic influences, at this point in a routine refraction.

Color tests can be made in one of two ways. The examiner can determine the patient's ability to successfully pass a Motor Drivers Color Vision Test[46] only, or the test can be made in such a way as to really determine the presence or absence of any defect of the retinal centers which control color-vision. The Motorists Color Test is simply made by having the patient distinguish between red, signal-green and yellow. Most partially color-blind patients easily pass this test as patients suffering from this defect can usually differentiate between colors of such different hues. Silver[47] suggests the examiner procuring from the Traffic Semaphore Manufacturing Companies small discs of colored glass of the exact shades as used in the semaphores themselves. These discs being then mounted before an enclosed elctric lamp in such a way that the light shines through only one disc at a time, the patient naming the color as the disc is changed. This type of test does well for survey work and will eliminate those cases affected with a very severe color disorder, but is naturally ineffective as a thorough diagnostic test, as only patients with the grossest defects are found.

A few of the more modern developments for color testing are the Lantern test[48,49], the Classification test[50] and the Jennings Self Recording Color Test[51]. The Lantern test, is as its name implies, a test made by having the patient view various combinations of colored, smoked and frosted glasses through aperatures of various sizes. The Classification test consists of four test colors and one hundred and eighty confusion colors, the patient being instructed to match or sort out those shades most nearly conforming to one or more of the original four test colors. The Jennings Self Recording Test for Color Blindness embodies the same features as does the Classification test, having the one advantage that the patient, instead of handling the test objects, thus soiling them, merely marks a record sheet, giving the location of each set of colored wools which fall into the logical groups of either red or green. Any of these tests are good, and they all are simply made. The use of at least one of them should be made in every routine refraction. In making a test for color-blindness it is well to keep in mind the fact, that while in most patients whose color vision is deficient the fault will be found to be congenital, the defect may, nevertheless result from an atrophy of the optic nerve, central tumors, locomotor ataxia, paresis, traumatism, syphilis or alcoholic and tobacco poisoning[52], thus making a rather searching investigation necessary in each case where either a partial or a complete color-blindness is found.

Perimetry

The word perimetry is used as a general term to apply to the measurement and charting of the visual field[53]. By this is meant the measuring of that portion of the retina that is actually used, directly or indirectly,

by the patient in an effort to see. In reality, perimetry is a subjective ophthalmoscopic test. As is well known, opthalmoscopy is objective; that is, the results of the test depend entirely upon the examiner's ability, while in perimetry one actually charts the field of vision while the retina is at work, relying entirely upon the answers of the patient, thus making it an entirely subjective test. This is our only means of actually knowing whether the sensitive layers of the retina are functioning as they should, inasmuch as the retina may appear normal to the examiner while using the ophthalmoscope, and yet the visual field may be much smaller than normal or various types of scotomata may be present to dimish visual acuity.

To determine the exact field of vision and color perception, the examiner has four general methods of procedure at his command: First, the hand test; second, the Morton perimetric test; third, Campimetry, and fourth, the Perimetric test proper. I shall describe these various methods briefly in the order named.

The Hand Test

In this procedure, the most inaccurate method of taking the patient's field of vision, no equipment is needed. The examiner's field of vision must be normal, for it is by means of comparing his own field with that of the patient that the test is carried out. The method of procedure is as follows: The patient is first seated comfortably. The room is well illuminated. The examiner next seats himself directly in front of the patient and at about an arm's length away. Assuming that the examiner wishes to determine the approximate extent of the indirect form field of the right eye, he covers the patient's left eye with his (the examiner's) right hand, at the same time closing his own right eye. The patient is then instructed to look with his right eye straight ahead into the open left eye of the examiner. The examiner then takes some small object—a pencil, for instance—and holds it in his left hand midway between himself and the patient as far out to his left as possible. He then instructs the patient to tell him the moment the moving pencil can be seen, as he draws it in towards him. At all times, I repeat, the patient's direct line of vision must be straight ahead and fixed upon the left eye of the examiner, and the examiner must be looking straight into the right eye of the patient. Now, if at the moment the object becomes perceivable to the examiner the patient also indicates that he is also aware of its presence, the external field of indirect form perception may be regarded as normal in this meridian. The examiner then proceeds to make this test over in various other meridians and then reverses the procedure for the patient's left eye. If the patient's answers conform to the examiner's ability to see the test object, the patient's form field may be regarded as normal. Any marked shrinkage in the size of the field

in any of the various meridians tested immediately calls for a more thorough examination of the patient's entire field, as it is easy to see that this test is, at best, quite crude and only suitable for roughly measuring the external limits of the form field. The testing of the patient's field of color perception, and direct visual centers, must be left to the more refined methods of perimetry, such as the following:

The Morton Perimetric Test

The instrument needed in making this test is the Morton perimeter. This is a rather new instrument and one that should prove very popular with all refractionists, as it meets the three requirements of all good instruments. It is quick and easy to operate, inexpensive to buy and accurate for all general types of perimetric work. The instrument consists of a spherical one-quarter inch brass frame, fourteen inches in diameter, from which are fastened twelve brass rods, which form the radii of the fourteen inch circle. These rods, or meridians, along which the test is carried out, meet at a common center or pole of the instrument. This pole is made to correspond to the macular region of the eye, by the insertion of a small metal disc showing the blind spot. Upon each of these grooved semicircular meridian rods, which are measured off in degrees, are placed four small movable markers which slide along in the grooves. The markers consist of, first, the white, and then the three principle colors, blue, red, and green. These forty-eight markers form the test objects with which the test is made. The entire instrument or frame is finished in a dull black and is mounted on a handle which extends downward from the fourteen inch circular inner edge of the instrument. From this handle a metal sighting device, at the pole or macular region of the instrument, a small hole has been made to assist the patient in the matter of fixation.

In using the Morton perimeter, the patient is seated in a well illuminated room, but not facing the source of light. This is an important matter, for should the test be made with the patient facing an open window or a strong light it would be nearly impossible to distinguish the various colors of the markers and would also diminish the pupillary area to such an extent as to materially cut off some of the visual field.

The patient being comfortably seated, his left eye is now excluded. This can be done in one or two ways; either by using a bandage or folded linen cloth to exclude the eye while testing its mate, or by the use of the small black silk monocular eye patch which has the silk tapes attached. The silk tapes tie behind the patient's head. The latter method is quite preferable. The patches are quite inexpensive when purchased in quantity and although a new patch is required with each refraction, of course, the ease of application, plus its obvious advantages over bandages, make it quite preferable.

The left eye now being excluded, the patient is handed the perimeter. He is requested to place the small sighting device directly below the right eye. This being done, he is asked to look through the small aperature at the center of the macular region or pole of the instrument, directly opposite his right eye. This is his point of fixation during the entire test, and the examiner must impress upon the patient the necessity of fixing his attention on this point. This is one of the most difficult features of making or charting the field of vision. The average patient finds it extremely difficult to keep his or her attention fixed on a given point for any length of time while markers are moved about. The natural tendency is to rotate the eyeball with the movement of the marker, but with a little patience the examiner will find it not at all impossible to get and hold the patient's attention during the examination and plotting of the field.

In using the Morton perimeter the "visible to not visible" mode of procedure is preferable. By this is meant that the markers are started out at the macular region and gradually moved along the meridian rods until they reach a point where they are no longer seen by the patient, as he "fixes" on the small aperature at the pole of the instrument. It is well, as I said, while using the Morton perimeter to use the "visible to not visible" mode of charting the field. The reason for this is as follows: The logical method in taking the field is to use the white marker first, thus making the form field of indirect vision. As this field is the largest possible field, the white markers would be slipped further along the meridian rods than any of the colored markers which are to follow. After finishing with the form field the examiner then proceeds to chart the various fields of color perception, starting with the blue, then the red, and then the green. The reason for this order is that the field of color perception for blue is normally larger than that of red, and that of red larger in turn than that of green, although as Ferree and Rand[54] pointed out in 1924 this is not true if the stimulating light is of sufficient intensity. Thus one can see that in using the "visible to not visible" method of taking the fields the examiner can string all four markers on each meridian rod in succession without the markers interfering with each other in any way.

The examiner now instructs the patient as to the method of procedure, stressing the point of visual fixation and moving the markers to show just what is to be expected of him. The test can be started in any meridian, the white marker moved inward along the meridian rod until the patient indicates that it is no longer visible to him. The marker is then left in this position and the white marker on the next meridian rod is taken and also moved inward until it is also lost sight of. This continues on all meridians until all the white markers are in the positions indicated by the patient as the limit of his form field in the various

meridians. If the arrangement of the markers corresponds to a normal field the case may be regarded as normal; if there is a marked shrinkage of the form field certain types of pathology are indicated.

The next step is that of taking the color field. This, as I have said before, is started with the blue markers. These markers are moved along the meridian rods, just as were the white ones, and stopped the moment the patient indicates that he no longer perceives the marker as blue. This is done in all meridians and when finished is followed by the red markers, the procedure being the same as in the case of the blue ones. The green markers are used last and in the aforementioned way. When the markers are all in place one has not only the indirect field of form perception charted, but also the three principal fields of color perception before him, and any discrepancies can be noted. The Morton perimeter is an excellent one for outlining the various fields, but, like most perimeters, is quite useless in charting small scotomata, finding the blind-spot or in fact taking any data on the direct visual centers and the immediate surrounding area, require a type of perimeter known as the stereocampimeter.

Campimetry

The stereo-campimeter is an instrument devised for the purpose of assisting the examiner in the matter of plotting the central visual field. In this purpose the inventor has succeeded very well, for the instrument is, when properly used, highly accurate and easily adjusted. The instrument consists of a substantial metal base of oblong shape, with vertical pillar containing an elevation device, which carries the object stage and holder for the stereo lens system. This system includes a stereoscopic viewing device and eye screen.

The stereoscopic viewing device just mentioned consists of two prismatic lenses mounted in a frame. These lenses can be rotated to correct any hyperphoria the patient may have, by simply turning a small thumbscrew at the edge of the frame. The lenses can also be adjusted in horizontal position to assist the patient in getting a clear image of the object stage.

The object stage, as generally used, consists of a black slate ruled with vertical and horizontal white lines. It is upon this slate that the markers are held and the central field of direct vision plotted.

Campimetry, as this type of perimetry is usually called, is the only form of field taking that is done binocularly. This, in itself, is an immense advantage over the monocular type of procedure, as the average patient finds it much easier to fix his attention on a given point with both eyes than he does with one.

The patient, wearing his distance correction, is seated before the instrument in the best diffused light possible, preferably daylight, and directed to look through the stereoscopic system, which is then focussed,

at the campimeter slate. Small test-objects are now moved about upon the slate while the patient's vision is directed to a central point of binocular fixation, which to the patient appears to be in the center of the slate. As the markers are moved about the patient indicates by the tapping of a bell or by some other signal the moment the marker disappears and reappears. With the aid of a white chalk pencil, with which to draw upon the slate, the blind spot and any scotomata present can be definitely located and charted. Thus, the exact workings of the macular area of the retina can be examined and even the smallest defects noted.

Rotating Arc Perimeter

The fourth form of field taking is that in which the rotating arc perimeter itself is used. Instruments of this character will be found in many of the well equipped refracting rooms throughout the country, the various makes being about the same and all equally accurate. In discussing the instrument and its uses I will use as a model the McHardy-DeZeng. This instrument consists of a metal base, upon which is fastened, at one end, a vertical adjustable chin rest, and at the other end a vertical rod which holds the metal rotating arc, the meridian scale, the carrier drum and adjusting device, and the automatic recording pencil or stylus with sheet.

The instrument is used monocularly, one eye bandaged with the eye patch, as before mentioned, the patient being seated in a comfortable manner before the instrument, with head resting upon the chin-rest. The room should be well illuminated, daylight preferred. The perimetric sheet for either the right or left eye, whichever field is being plotted, should be put in place at the rear of the instrument and the patient directed to "fix" upon a small white stationary marker placed directly before the patient's eye at the center of the arc. The arc is now swung into position, most examiners starting in the nineteenth meridian. In taking the form field the five millimeter white marker is turned into position on the movable carrier. Now either the "visible to not visible" mode of moving the carrier or the "not visible to visible" mode may be used. If the latter is chosen, the examiner first places the carrier at the extreme end of the arc and then slowly slides it in along the arc towards the center until the patient indicates that the marker has become visible. The carrier is then stopped and its position on the arc is registered on the perimeter sheet by pressing this sheet against the automatic movable pencil or stylus. This being done in all meridians, the resultant plot will show the extreior edge of the form field of in direct vision. Should the examiner elect to use the "visible to not visible" mode of charting the field, the carrier would be placed at the center of the arc and then slowly moved along the arc until the patient could no longer see it. This the writer believes to be the best method,

inasmuch as any large defects of the central portion of the retina could be plotted at the same time that the form field is being taken. The color tests can also be taken in this way, the marker changed to blue, red, yellow or green and the carrier moved from the center along the arc until the color is no longer distinguishable. With the automatic record device, this instrument becomes the most accurate in taking form fields and is of great assistance in enabling the examiner to determine whether the patient's vision is impaired by any pathological defects of the retina.

It is, therefore, apparent that two types of instrument should be used in taking and charting the visual fields if the greatest accuracy and most complete data are desired. Such instruments are the stereo-campimeter, for obtaining the central fields, and the Morton or the rotating-arc perimeter, for plotting the indirect fields.

The diagnostic information to be gained by the use of these field plotting instruments, may briefly be summed up as follows: A concentric contraction of the external limits of the form field as in amblyopia, leutic chorio-retinitis, chronic nephritis, pregnancy, etc., etc.; a hemianopsia resulting from a diseased condition of the visual tract and chiasm; sector-like defects as resulting from optic atrophy; scotomatas of various kinds due to lesions of the brain, optic tracts, optic nerve or retina, or finally a comcentric contraction of the form and color fields as found in cases of glaucoma[55]. These are but a few of the many types of pathology which produce changes in the size and form of the visual fields, and as in ophthalmoscopy, it is well for the examiner to remember that any marked change from normal indicates pathology in or around the eye and orbit or an infection or poisoning which is effecting the optic nerve and retina. Cases showing these perimetric diagnostic signs require specialized treatment.

In those ocular cases however wherein the external ocular inspection discloses no abnormalities and in which the ophthalmoscopic examination, and sphgmomanometric findings, the color perception tests and the fields of vision are proved normal, the case may properly be assumed to be one of a purely refractive defect, and the symptoms if any may be regarded as reflexes due to either some anatomical defect such as corneal astigmatism, or to an imbalance of the convergence-accommodative structures.

We next turn to the ophthalmometer for what diagnostic information can be secured by the use of this instrument.

Ophthalmometry

The Ophthalmometer is used chiefly to measure the principal and secondary meridians of the anterior surface of the cornea in dioptres, or

the radius of this same surface of the cornea in millimeters. The dioptric system of measurement is usually preferable.

The outer surface of the cornea is convex, either spheric, toric, or irregular in its curvature, and it is this information along with the dioptric power, if spherical, that it is desirable to secure at this time.

In measuring the dioptric value of an eye, the cornea of which is spherical in shape, the writer has found that a cornea which has a convex dioptric equivalent of from thirty-eight to forty-five dioptres in strength is usually a diagnostic symptom of a hyperopic eye. In measuring the anterior surface of cornea which is spherical in shape and whose dioptric value ranges from forty-five to fifty-two dioptres in strength as measured with the ophthalmometer, the writer assumes this latter cornea to be indicative of myopia. This does, of course, not always hold true.

When the cornea is found to be toric in shape, for instance, having a convex surface equal to forty-three dioptres in the horizontal meridian and forty-five dioptres in the vertical meridian, one has a case of corneal astigmatism. Such mal-curvatures of the cornea are cases of true astigmatism and should be corrected to their fullest possible extent by means of cylinders incorporated in the prescription. It is not always possible to prescribe the full correction at once as the action of the ciliary muscle upon the crystaline lens may be of such nature as to produce a mal-curvature of this lens to offset the corneal astigmatism. When this is true, it is well to prescribe as much cylinder as possible, instructing the patient to wear the temporary correction for a period of thirty to ninety days and return to have a stronger correction prescribed. In this way, by slow stages the false lenticular astigmatism will subside and the full corneal astigmatic correction will become accepted.

In cases of irregular astigmatism, it is usually impossible to prescribe findings as given by the ophthalmometer. Here the examiner will have to rely upon the retinoscope to enable him to give the patient the best possible visual acuity. However it is in cases of this kind that the ophthalmometer will prove invaluable as it will fore-warn the examiner of the later difficulties which he will experience with the case.

The ophthalmometer is valuable also as a diagnostic instrument in cases of incipient cataract as well as an aid in preventing the further development of cataracts through the information gained by its use. Ryer[56] brings out these points splendidly as follows:

"Conceding the ability of the ophthalmometer to measure only the anterior surface of the cornea, any possibility of aid from it in the diagnosis of cataract seems remote, but herein lies an example of the great, though too often hidden, value of correlated tests in ocular investigations. The retinoscope may show an irregular movement, sufficiently marked to warrant calling the condition irregular astigmia. Irregularities

of the cornea may signify scars, ulcers, pterygium, conical cornea or still other corneal abnormalities, but irregularities in the crystalline lens are frequently indicative of changes which develop into cataract.

"Thus if we can differentiate lenticular from corneal irregularities we have a most important diagnostic clue. We cannot make this differential diagnosis with either the retinoscope or the ophthalmometer alone, for the ophthalmometer might show a regular cornea and give no hint of possible lenticular irregularities while, on the other hand, the retinoscope may show irregularities but afford no means of knowing to which medium they should be ascribed.

"If, however, the retinoscope shows irregular astigmia while the ophthalmometer shows no corneal irregularity to account for it, we are led to assume that the irregularities are due to changes in the crystalline lens.

"Such crystalline changes are certainly sufficiently significant to warrant most careful investigation and constant supervision. If cataract is to be checked or retarded in development, surely the best chance lies in treatment at the earliest possible moment.

"Hence the peculiar value of the ophthalmometer in at least arousing our suspicion of this lurking menace before any opacity gives actual warning.

"Few absolute rules obtain in optometry but, as a safe working rule, it may be assumed that in those cases where the retinoscope shows irregular astigmia not accounted for by irregular corneal ophthalmometric findings, incipient cataract should be suspected."

As a rule the miral reflexes are white in color providing white mires are employed in the ophthalmometer but occasionally we find them tinged with color over their entire surface. This color may be of diagnostic value. Drakeford[57] claims; "A healthy eye in a healthy person will give clear and brilliant reflexes, the outlines of the mires being everywhere clearcut and definite. These are found mostly in hypermetropes of low degrees where the person is young and vigorous.

"An eye which carries more or less inflammation of the tissues will show a reddish halo, or atmosphere, and a subdued reflex.

"Eyes of neurotics and those suffering from high nerve tension or inflammation of the nerves, such as nervous prostration, will show a steel-gray atmosphere and subdued miral reflexes.

"Myopes usually show a reddish atmosphere."

Ryer[58] has this to say on the same subject: "The coloring of the miral reflexes is not easily accounted for. It may be due to chemical changes in the lacrymal fluid or to changes in the texture of the corneal tissue which cause the latter to act as a diffraction grating. A loose textured cornea could be conceived as responsible for the large red waves and at the same time for the myopia on account of its lack of resistance

to intraocular tension, whereas a tense cornea would be likely to accompany a highly strung individual and because of its closely knit texture, send back the smaller blue waves, the steel-gray waves of Drakeford's; but while this hypothesis seems plausible it is only offered tentatively, awaiting more definite data." Skeffington[59] reports similar ophthalmometric diagnostic results.

While neither Drakeford, Ryer nor Skeffington, are in position to definitely state the diagnostic value of colored corneal reflexes, they have, nevertheless advanced several interesting hypotheses which will bear further fruitful investigation.

The technic in ophthalmometry is in itself so simple, regardless of type of instrument used that this phase of the subject, as well as that of choice of instruments is let entirely to the practitioner himself, the writer being merely content to say that no routine refraction should be completed without the specific information recorded as to the corneal curvatures and possibly also the color of the corneal reflexes.

Static Skiametry

Immediately following the recording of the ophthalmometer readings the examiner should proceed with the objective skiametric tests[60], the first of these being static skiametry[61], or a skiametric test made with the accommodation at rest.

The test is made by ascertaining the patient's point of reversal by means of lenses while the patient views some distant object placed at six meters or more away, to insure the fullest possible relaxation of accommodation, the examiner at the same time working at some known distance from the patient.

The writer having used various distances has finally accustomed himself to a fifty centimeter working distance. The advantage of the fifty centimeter working distance being that it is far enough from the patient to assure accuracy yet near enough to enable the examiner to conveniently change the lenses as needed before the patient's eyes. Theroretically, at this distance, two spherical dioptres should be deducted from the correction which produces a point of reversal but because of the lag of accommodation[62,63] the writer has found a One and One-half dioptre spherical deduction to be more nearly correct.

In certain cases of ciliary cramp or in most cases of exophoria it is advisable to have the patient wear if possible without producing diplopia from Four to Six, base-in prism dioptres in a trial frame for from fifteen to thirty minutes before the skiametric tests are made, this procedure being followed to more fully relax the convergence-accommodative functions[64]. The writer has also used with good advantage, repression lenses[65], having the patient wear such a temporary fogging correction for from one to three weeks, to relax if possible, by this

method a ciliary cramp. As to the choice of retinoscopes used the writer recommends the cord-handle electric retinoscope because of its even, never varying source of illumination, which makes this type far superior, in his estimation, to the battery-handle instrument. The Streak or Band retinoscope is an added skiametric aid, particularly in cases of astigmatism, this being the newest development in skiametric instrumentation.

The First Dynamic Skiametric Check Test

The dynamic skiametric tests vary from the static in only one respect, *i. e.* the accommodation is active in the dynamic tests instead of inactive as in the static. The first dynamic check test is made immediately following the static skiametric tests, the patient in this instance keeping the full static findings before his eyes, less of course the deductions made for the working distance. In making the dynamic skiametric test the patient is instructed to change his fixation from the object viewed at six meters to another fixation target placed at the same distance from the patient as is the examiner. In the writer's routine office work, this is, as has already been mentioned, fifty centimeters. If the examiner now finds a point of reversal he can rest assured that his static skiametric findings are correct. Should he find, in a patient under normal presbyopic age, that it takes from one-half to one dioptre of plus sphere to bring out a dynamic point of reversal, the examiner will know that there is present what Cross[66] terms a latent hyperopia, and what Sheard[67] and Nott[68] term a normal lag of accommodation, which static skiametry has merely failed to reveal. This is without a doubt a normal condition, being what is usually found when making this check test.

Should the examiner however find more than one dioptre of variance between the static findings and the dynamic findings, he must make additional effort to further relax accommodation at a distance thus enabling him to crowd on more plus, or else must decide to prescribe a somewhat stronger correction for near-point work than that to be used at a distance.

In this connection the writer believes as does Sheard and Nott, that the first one-half to one dioptre of variation represents a normal lag of accommodation, but feels that a difference of more than one dioptre in a patient less than thirty-eight years of age, who is in normal health, indicates both the normal lag of accommodation as well as some latent hyperopia, which should be corrected.

In presbyopic cases naturally, the variance will be more than the normal just refered to, the correction of the ciliary defect being taken care of later in the course of the routine refraction.

The static and dynamic skiametric findings being recorded the patient is dismissed with an appointment for a post-refraction[69] on the following day.

The examiner now has in his possession data which will enable him to outline a plan of treatment for the case, before the patient returns for what is, in most cases the final refraction, or what is more properly termed, the Post-Refraction. The symptoms as recorded in the history; the uncorrected monocular visual acuity; the uncorrected phoria tests giving the examiner a clue to the nerve tonicity; the various tests for pathological symptoms; a test for corneal mal-curvatures and finally the objective refractive status of the eyes. What more could be asked in the way of useful information with which to enable the examiner to formulate a course of action with reference to the particular case at hand?

The Post-Refraction

Static Skiametry

The Post-Refraction starts with a repetition of the static skiametric test as on the previous day. At this time it is frequently found advisable to have the patient wear a pair of base-in prisms for a short period prior to making this skiametric test. The findings of this second static test are then recorded, and carefully compared with those of the same test made on the previous day. Wiseman[70] suggests flooding the examining room in which the patient is resting with blue light for a period prior to making the test thus further inducing complete relaxation. As the irritating or stimulating as well as restful effects of color on the eye and nervous system are well known, this suggestion would be well worth investigation.

The Second Dynamic Skiametric Check Test

The second dynamic check-test is next made in exactly the same manner as was the first, as has been already outlined, its findings being also recorded and compared with the dynamic findings of the previous day. The full dynamic findings are now left in place[71] and a card, with cross made up of a set of vertical and horizontal lines ruled upon it, is placed before the patient at about the dynamic fixation distance of fifty centimeters.

The Monocular Cross Cylinder Accommodative Test

The cross cylinder test is now made as a check test on the static and dynamic skiametry tests. The purpose of the test is simply to avoid under or over correction of the patient.

The technic is monocular. A cross cylinder is placed before one eye of the patient the other being covered, the cross cylinder having the axis of the plus cylinder at 180. If the horizontal lines are blacker than the vertical, more plus is to be added, or if the vertical are blacker than

the horizontal, the plus is to be reduced. Normally all lines should look alike, all slightly blurred[72] or out of focus. Peckham suggests not only using the usual cross cylinder composed of a —0.50 D. Cyl., at right angles to a +0. 50 D. Cyl., but rather having a set of them made as follows:[73]

No. 1. —0.25 D. Sph. +0.50 D. Cyl. axis 180.
No. 2. —0.50 D. Sph. +1.00 D. Cyl. axis 180.
No. 3. —0.75 D. Sph. +1.50 D. Cyl. axis 180.
No. 4. —1.00 D. Sph. +2.00 D. Cyl. axis 180.

The advantage of the set being that in certain cases the more commonly used cross cylinder (No. 2) will cause such a decided blur and confusion that the test becomes too difficult to enable the examiner to secure accurate subjective findings. In these cases cross cylinder No. 1, could be used to advantage. On the other hand claims Peckham, one occasionally examines patients who are unaware of any blurring change in the appearance of the lines when the No. 2, cross cylinder is placed before the uncovered eye. In these cases either cross cylinder No. 3 or No. 4 could be employed to advantage.

The Corrected Subjective Distance Acuity of Vision Test

With the final dynamic skiametric correction as checked with the cross cylinder, in place, the patients attention is directed monocularly to the set of test characters previously mentioned when the patients visual acuity was recorded uncorrected. Starting with the 20/300 line the patient is instructed to read as many of the characters as possible and a record is made of the smallest chart read with the full dynamic findings in place. This the writer believes to be important as it gives the examiner definite data as to the patient's ability to see clearly or otherwise with his full correction in place when hyperopic or with his near-point correction in place if myopic.

The writer does not employ the full fogging system[74], preferring this type of modified fogging as he has found that it saves time and is decidedly less confusing to the patient. The subjective test when made in this manner and carried out in conjunction with reliable objective tests, accurately made, will give as good if not better results than the full fogging routine as formerly advocated.

After recording the monocular visual acuity with the dynamic findings in place these are then modified if necessary, as in the full fogging system to enable the patient to see most clearly, the writer using an astigmatic fan and test characters for this purpose.

It is well however to mention at this time that the modification of the skiametric findings, while done as in the full fogging system, is in the writer's belief, done more intelligently than it would be were only

that system followed. With the previous knowledge of the patient's phorias; with the known corneal curvatures and with the distance skiametric findings at hand the examiner is now getting into a position to not only prescribe a correction which will give the patient normal or at least as near normal vision as possible, but also one which will maintain a proper working balance between the convergence-accommodative functions. At this point in a routine refraction the examiner cannot as yet prescribe, but data can be recorded which will later, when all the correlated tests have been made, be worked into a formula that has been carefully studied out, not only to improve vision but also to conserve nerve force and to prevent fatigue.

The Dominant Eye

The monocular subjective visual acuity testing is immediately followed by a test to determine the dominant eye of the patient. This is done by having the patient point to the uncovered eye of the examiner, he being some fifteen feet away. The patient will line up his fore-finger and his dominant eye with the uncovered eye of the examiner. The information gained by this test is important in both the final subjective check test, that is the comparison test next to be made and also in the arrangement of the prismatic powers in the final formula prescribed, should it be necessary to incorporate prisms in the prescription.

Distance Comparison Tests

Following the determination of the dominant eye a visual comparison test is now made at twenty or more feet. It is naturally of the utmost importance to get the patient's monocular vision equal if possible, and with this in mind the comparison test is now made. The technic is simple. Both eyes are covered with opaque discs and first one and then the other is uncovered, the patient simply stating which eye has the sharpest acuity of vision, if any difference is noted. Should the vision be unequal effort should be made to eliminate this inequality, subjectively—keeping the dynamic and static findings always in mind as well as the fact that the visual acuity of the dominant eye should be equal to, if not slightly better than, that of the nondominant eye. This latter point is important as the writer has frequently found it advisable to fog the vision of the nondominant eye a very small amount to get the greatest binocular comfort, in cases where the corrected visual acuity of the nondominant eye was somewhat better than that of the dominant eye.

Determination of the Patient's Visual Working Range

The examiner next turns his attention to a more detailed survey of the patient's ability to see normally and comfortably at the near-point.

Obviously the first type of procedure must be to definitely determine the exact distance the patient is called upon to use, in his or her various vocations from day to day. The history has already given the examiner the patient's occupation as well as hobbies which may effect near vision and it is but the work of a moment to check the near-point ranges with the tape. The examiner should use a steel tape in measuring these distances, insisting at the same time on the patient getting into exact working or reading posture so as to enable him to take these measurements as accurately as possible. The occupational near-point data is recorded as follows:

Patient habitually holds reading matter at, from.........to.........cm.
Patient's clerical work requires a near-point focus of, from.....to.....cm.
Patient's mechanical work requires a near-point focus of, from....to...cm.
For Music Patient requires a near-point focus of, from......to......cm.

The Third Dynamic Skiametric Check Test

The third dynamic check test is now made at the patient's occupational near-point. This does not mean the patient's near-point of accommodation but rather the distance at which his or her eyes must focus the greater portion of the time, while at their work. The test is made with the subjective distance correction in place, the spherical addition for near-point work being added as needed until a point of reversal is reached.

Should the dynamic findings which produce a point of reversal at the occupational near-point exceed the subjective findings by one or more dioptres the examiner at once knows that either there is a latent hyperopia present which must be corrected or else that the patient is somewhat presbyopic. In either event, near-point tests from this point on must be made with the full occupational near-point reversal findings in place, less the deductions which are made because of the normal lag of accommodation. These deductions are as follows: In patients from three to thirty-five years of age, deduct one dioptre. In patients from thirty-five to fifty years of age deduct, three-fourths of one dioptre. In patients from fifty to sixty-five, deduct one-half or a quarter of one dioptre. In patients over sixty-five years of age, no deuctions should be made.

For example, a patient whose static findings, checked with the subjective distance tests give a resultant distance formula of O. U. plus 1.00 D. Sph., and whose age was twenty years, and whose occupational near-point was sixteen inches and whose dynamic near point of reversal was O. U. plus 2.50 D. Sph., it would indicate a latent hyperopia of, in the writer's judgment, one-half dioptre. Methods must then be employed in this case to get the patient to accept this half dioptre of additional plus for general wear.

On the other hand, however, in a similar case, the patient being forty-five years of age rather than twenty, the dynamic readings would be interpreted to indicate a presbyopic condition and the formula would become a bifocal one in form, the distance portion being O. U. plus 1.00 D. Sph., and the near-point addition being O. U. plus 0.75 D. Sph. It is to be remembered, however, that this is still a tentative formula, not one to be prescribed as the convergence tests are still to be made After the deductions have been made for the normal lag of accommodation the patient's corrected near-point of accommodation is then measured to check the third dynamic findings.

The Near-Point of Accommodation

In taking the near-point of accommodation the examiner uses the same steel tape which was used to measure the occupational near-point. The patient is wearing the full occupational near-point correction in a trial frame. The use of a trial frame is here important as the small type with which this test is made should be held along the tape stretched out in the direction which the patient usually looks when doing close work, the patient holding one end of the tape up to his chin, the examiner holding the other end of the tape at about the working point, he also holding the test card of small five point type along the tape. This card is then moved up along the tape towards the patient to the point where the type first become blurred. This position is then noted, it being his corrected near-point of accommodation. The writer does not as a rule make an uncorrected near-point of accommodation test, nor does he believe the test should be made while the patient is viewing the test card through any battery of lenses—inasmuch as the ocular position in the latter case is so unusual as to materially impair the findings. A record is then made of the third dynamic findings and of the near-point of accommodation in either centimeters or inches.

Subjective Positive Accommodation

Should the examiner wish to carry the accommodative tests further after taking the near-point of accommodation, he has access to the subjective positive and negative accommodative tests[75]. The writer has found however that a slight modification of these tests will in patients under forty years of age serve as an accommodative check test just as well and in a slightly simpler way. His technic is as follows: With the full near-point correction in place the examiner has the patient read the smallest type on a reading test card held at the occupational near-point or working distance. A pair of minus 3.00 Dioptre spheres are then interposed. In cases of normal accommodation the patient will, after a very slight pause, be able to continue the reading. Should the patient

be unable to read, the examiner at once knows that an accommodative insufficiency is present which will make prolonged near-point work difficult if not impossible. This modified subjective positive accommodative test is made merely to supplement or recheck the measuring of the patient's near-point of accommodation. A patient having an accommodative reserve sufficient to overcome a pair of minus 3.00 dioptre spheres, has according to Howe[76], sufficient accommodative powers to enable him to do near work with ease, providing of course the patient's convergence functions equally well.

The Determination of the Near-Point Correction

The examiner now having in his possession data relative to the patient's occupational near-point, the patient's dynamic skiametric findings at this distance, together with the results of the accommodative tests, is now in a position to tentatively determine just what reading or working addition if any is needed, keeping the above factors in mind. Care must be taken not to get the focal range of the near-point correction too near, as many patients are prone to underestimate rather than overestimate the distance at which they hold their reading or do their near-point work.

The patient at this point in a routine refraction should be asked to sit quietly to one side with the reading or working correction in place in a trial frame for at least a fifteen minute period to note the action of the accommodation-convergence factors while reading. This is of course, the subjective near-point test and should not be done hurriedly. To merely place the formula before the patient at the same time requesting him or her to read a few lines, and then stop is to invite error, inasmuch as most patients can call upon accommodative reserves for a few moments near work, whose ability to continue this near work would be materially impaired should they have to do so for ten or more minutes. In fact a half-hour to three-quarteres of an hour of reading at this time would be even more preferable, in making this subjective near-point test.

When this reading period is finished the patient is recalled and the near-point comparison test is made.

The Ocuppational Near-Point Comparison Tests

This test is made in essentially the same manner as is the distance comparison test. Both eyes being fully corrected are covered with opaque discs, and first one and then the other is uncovered, the patient viewing small type held at the occupational near-point. As in the distance comparison test it is essential to get both acuties of vision equal, this now being accomplished subjectively, keeping the near-point dynamic findings in mind as well as the results of the accommodative tests. The tentative near-point formula is then recorded.

The Corrected Distance Phoria Tests

The examiner next turns his attention to the patient's extrinsic muscles and their ability to function. The technic used in determining what are commonly known as the phorias and the ductions is simple, but the interpretations of the findings and their correlation with the findings of the accommodative tests is frequently exceedingly difficult.

For years we spoke of the "Power of the Muscles." We measured ductions in degree of what we thought was the extrinsic muscle's power to pull, yet more recent experimental work has somewhat altered these views and we are now coming to believe that the ductions are more really a measurement, if such a thing is possible, of the patient's ability to use the fusional powers, as it is obvious that many patients having what is termed a low adduction can, when called upon, turn their eyes nasalward to such a degree that the inner margin of each iris meets its respective inner canthus, a feat requiring far more "power" than we have ability to measure with the most modern of instruments.

For years also we believed that esophoria as sometimes found in making a phoria test indicated a weakness of the external rectus or an over-development of the internal rectus, while an exophoria indicated a weakness of the internal rectus or an over-development of the external rectus, and an orthophoria at twenty feet was supposed to indicate an ideal balance of the extrinsic horizontal recti muscles. The more modern[77] optometric thought is now that these tests merely indicate the present status of body-nerve tonicity, if I may use such a term, rather than the ratio of power between the muscles themselves.

Barring cases of structural anatomical muscular defects and cases of paralysis it is now becoming common belief that in nearly every case the extrinsic muscles have the ability to properly function, providing the nerve centers controlling their functions are sufficiently developed and also providing the nerve pathways are sufficiently vitalized to permit these nerve impulses to reach the muscle itself.

Assuming this hypothesis to be true the problem before the examiner ceases to be one of muscle and resolves itself rather into a study of various nerve mechanisms and centers. As Wiseman[78] in one of his lectures so aptly puts it, "the optometrist of today, becomes the neurological diagnostician of tomorrow." However, the technic of the phoria and duction tests remains in a large measure the same as before, but our interpretation of the findings has, in a sense changed, although on many points all authorities are still at variance.

The first of these diagnostic tests to be made is the corrected phoria test. Its technic is as follows: The patient being first fully corrected for distance is instructed to fix a small round light placed at twenty or more feet before him on a level with his eyes. A white maddox rod is then placed before one or the other eye in such position that the patient

reports seeing a small round light and a vertical white streak of light. The writer does not use a red disc or a red maddox rod in conjunction with this test as frequently suggested[79] believing as does Brown[80] that its use alters the findings of the test, making patients about one degree more esophoric or one degree less exophoric than is shown without its use. The patient then indicates the position of the streak of light as it relates to the round white light. Should it fall to the right or left of the light, prisms are interposed to bring the two together and the findings being then recorded in prism degrees of deviation of the visual axis. The maddox rod is then turned so as to produce the effect of a horizontal streak and the test repeated, the findings again being recorded. The correction is then changed if necessary to the patient's near-point occupational correction, and the test repeated at this distance, the findings being recorded as before.

The Duction Tests

The examiner then makes the duction tests. The patient's distance fixation is changed from a small round light to a row of $20/30$ test characters, providing of course, that the patient's distance corrected visual acuity is normal. The maddox rod is removed and as a rule a pair of Risley rotary prisms are turned in before the corrected eyes of patient. Instructing the patient to at once report any blurring or doubling-up of the test characters which may take place, the examiner next turns in base-in prism power until the patient reports two images. The power of the base-in prism is then slowly reduced until the patient reports but one image again. The test is carried out with distance fixation for both the external recti as above, the internal recti using prism base-out, and the vertical muscles using for this test prisms base-up and base-down, the tests being made first with one eye and then with the other, the findings being recorded as follows:

Distance Duction tests.

O. D. Abd. $7/4$ Add. $20/16$ Infra. $2/1$ Super. $2/1$

O. S. Abd. $8/4$ Add. $18/15$ Infra. $2/1$ Super. $2/1$

the fractional notation being preferred, the numerator being the notation denoting the break or doubling-up, the denominator denoting the recovery.

The test is carried out at the patient's occupational near-point in exactly the same manner, the patient having first a vertical row of characters and later a horizontal row for fixation. The near-point duction findings being recorded as were the distance ones. In this connection it is well to note that Peckham[81] has developed the F-L and other fusional development cards to a point where they are frequently of material aid in diagnosing convergence insufficiencies and in relieving them.

The Binocular Accommodative-Convergence Cross Cylinder Test

The technic of this test is binocular. The cross cylinders are interposed before the patient, he also having before his eyes his full near-point occupational correction. The card with ruled crossed lines upon it is then placed at the occupational near-point. A ten degree[82] base-down prism is now placed before the patient's right eye. This produces a vertical diplopia. The patient is then instructed to fix the upper cross and the cross cylinder technic as already outlined is repeated. The same procedure is then gone through for the lower cross. Any changes in the near-point occupational correction necessary to make the lines of both crosses equally blurred now being made. The patient is then asked to state the relative position of the two crosses. Should the lower cross have moved to the right or the left as the strength of the correction was changed, the change must either not be made or the correction must be rechecked as the test indicates that an increase of the correction will upset the binocular accommodative convergence balance already gained by previous tests or prisms must be added to offset the change. On the other hand however, changes of correction as indicated in this binocular cross cylinder test which do not alter the relative positions of the two crosses can be made with the full assurance that both the convergence faculties and the accommodative faculties are normally functioning together.

The actual routine of a refraction closes with the making of the patient's binocular accommodative-convergence cross cylinder test, yet the most important phase of refractive work still remains to be done. This is making the diagnosis. The examiner now has before him data regarding the onset of the trouble, the previous and present symptoms, the presence or absence of diagnostic signs of pathology or anatomical abnormalities, the corneal curvatures, the static and dynamic skiametric findings, the near-point accommodative findings as well as the results of the patient's phoria and duction tests. All these data are present and the success or failure of the handling of the case depends upon the examiner's ability to correlate this material in such a way as to insure proper interpretations, thus permitting the examiner to prescribe a formula which will enable the patient's convergence-accommodative functions to work in a normal and perfect harmony.

To illustrate best how this can be done the writer has prepared the following cases, which will bring out many of the factors to be considered. In these cases it has been assumed that there is no pathology present, and that each hypothetical patient is in good health. It has also been assumed that no corneal astigmia is present. These assumptions must needs be made, to lessen the length of the case reports themselves. Obviously pathological cases must be corrected both as to their pathology and to their refraction. The treatment of the former as a rule taking

precedent over the latter, being generally administered by a physician. General health factors enter into refractive work to a very great extent, yet that is a field so large that for the present the writer is leaving it, with the single observation that no ocular correction will give its wearer comfort, whose general physical tone is materially subnormal. The astigmatic factors are ignored in these reported cases, not because the writer believes them to be unimportant but rather to simplify the data, he believing that most ocular examiners understand that astigmia must be fully corrected in all cases, irrespective of type.

Case One—Emmetropia, and Orthophoria.

Patient, age twenty-five. Uncorrected Phorias indicated one-half degree of Esophoria at twenty feet. The skiametric findings on the first day of the refraction were as follows: A point of reversal was reached with O. U. + 1.50 D. Sph., before each eye, the working distance being twenty inches, and the patient's fixation being twenty feet. The dynamic point of reversal with the fixation and working distance both at twenty inches was reached with a + 2.00 D. Sph. before each eye. These findings indicated no latent hyperopia, and because of the normal lag of accommodation they also indicated an emmetropic refractive condition. The refractive data as secured during the post-refraction on the following day was as follows:

Skiametry Static.
O. U. Neutral.

Skiametry Dynamic, fixation at 20 inches.
O. U. + 0.50 D. Sph.

The Monocular Cross Cylinder Accommodative Test.
O. U. The + 0.50 D. Sph., being left in place was shown to be an over-correction, test indicating that no plus sphere would be accepted.

The Subjective Findings.
O. U. No Correction Accepted.

The Dominant Eye Test.
The Right Eye.

The Determination of the patient's Visual Working or Near-Point Range. Average of fifteen inches.

Skiametry Dynamic fixation at fifteen inches.
O. U. + 0.87 D. Sph.

Near-Point of Accommodation.
5 inches.

Subjective Positive Accommodative Test.
8, or slightly more, dioptres.

Presbyopic Addition.
None.

Phoria Tests, fixation at 20 feet.
½ degree of esophoria.

Phoria Tests, fixation at 15 inches.
3½ degrees of exophoria.

Duction Tests, fixation at 20 feet.
O. D. Abd. 7/4. Add. 24/18, Infra. 2/1 Super. 2/1,
O. S. Abd. 7/3. Add. 26/18, Infra. 2/1 Super. 2/1,

Duction Tests, fixation at 15 inches.
O. D. Abd. 6/4. Add. 28/21. Infra. 2/1 Super. 2/1.
O. S. Abd. 6/4. Add. 28/21. Infra. 2/1 Super. 2/1.

Binocular Accommodative-Convergence Cross Cylinder Test.
Test omitted.

Comment:

The first case illustrates one which indicates an emmetropic condition combined with an orthophoria. The cases illustrates the findings as they would appear in a normal pair of eyes. As has already been mentioned, the examiner will get, with a working distance of fifty centimeters or twenty inches a static point of reversal with a + 1.50 D. Sph., and not a + 2.00 D. Sph., before the patient's eye in a case like this because of the normal lag of accommodation, and the dynamic findings will be found to be only slightly higher for the same reason. The monocular cross cylinder test, and the subjective tests support the static and dynamic findings, further indicating that no plus will be accepted for distance. The patient's occupational near-point was found to be fifteen inches. The dynamic test showed just the normal expected lag of accommodation at this distance, thus further confirming the previous tests. The patient's near-point of accommodation and subjective positive accommodative tests indicated a normal accommodative reserve, these findings supporting the previous findings of the dynamic skiametric test made with fixation at the patient's occupational near-point, of fifteen inches.

The results of the phoria test indicated a normal balance of the extrinsic ocular muscles, the exophoria at the occupational near-point being but slightly under the accepted physiological or normal exophoria at this distance. The ductions being normal, they confirmed the findings of the phoria test and there being no near-point correction the final binocular cross cylinder test was naturally omitted.

An ocular examination made in this manner gives the examiner a double check on each step of the work, and it is only when all the findings dovetail in such a manner that there can be no question as to the

exactness of the refractive procedure that the examiner can consider himself in position to finally prescribe for the case.

Case Two—Simple Hyperopia.

We will now assume that the same patient is slightly hyperopic, for instance, 1 dioptre. The findings will therefore be recorded as follows: A point of reversal was reached with O. U. + 2.50 D. Sph., before each eye, the working distance being twenty inches, and the patient's fixation being twenty feet. The dynamic point of reversal with fixation and working distance both at twenty inches was reached with a + 3.00 D. Sph. before each eye. These findings indicated a simple hyperopia, without any latent because of the relative sameness between the static and dynamic findings. The refractive date as secured during the post-refraction on the following day was as follows:

Skiametry Static.
O. U. + 1.00 D. Sph.

Skiametry Dynamic, fixation at 20 inches.
O. U. + 1.50 D. Sph.

The Monocular Cross Cylinder Accommodative test.
The + 1.50 D. Sph., being left in place was shown to be an over-correction the test indicating that + 1.00 D. Sph., was all the patient would accept.

Subjective Findings.
O. U. + 1.00 D. Sph.

The Dominant Eye Test.
The Right Eye.

The Determination of the Patient's Visual Working or Near-Point Range.
Average of 15 inches.

Skiametry Dynamic at 15 inches.
O. U. + 2.00 D. Sph.

Near-Point of Accommodation.
6½ inches.

Subjective Positive Accommodative Test.
7 or slightly more dioptres.

Presbyopic Addition.
None.

Phoria Test, fixation at 20 feet.
1 degree of esophoria.

Phoria Test, fixation at 15 inches.
3½ degrees of exophoria.

Duction Tests, fixation at 20 feet.

O. D. Abd. 7/4. Add. 24/18. Infra. 2/1. Super. 2/1.

O. S. Abd. 7/3. Add. 26/18. Infra. 2/1. Super. 2/1.

Duction Tests, fixation at 15 inches.

O. D. Abd. 6/4. Add. 28/21. Infra. 2/1. Super. 2/1.

O. S. Abd. 6/4. Add. 28/21. Infra. 2/1. Super. 2/1.

Binocular Accommodative-Convergence Cross Cylinder Test.

+ 1.00 D. Sph. was all that was accepted and therefore this is what is prescribed. The lines were equally indistinct and the addition of any plus to this correction caused the lower cross to move to the right, indicating a slight over correction causing an imbalance which manifested itself in an slight exophoria, or causes the vertical lines of the cross to become darker.

Comment:

The second case illustrates a simple hyperopia combined with an orthophoria. A study of the findings reveal the normal relation between the various skiametric findings, indicating no latent hyperopia, a thing later proved by the Binocular Accommodative-Convergence Cross Cylinder Test. The findings of the accommodative tests are slightly subnormal as is to be expected, and the comparison between the uncorrected phoria test and the corrected phoria test shows that the correction of the hyperopia does not materially upset the normal extrinsic balance.

Case Three—Latent Hyperopia.

We will now assume that the patient has a latent hyperopia of several dioptres. The findings will therefore be recorded as follows: A point of reversal was reached with O. U. + 2.50 D. Sph., before each eye, the working distance being twenty inches, and the patient's fixation being twenty feet. The dynamic point of reversal with fixation and working distance both at twenty inches, however was not reached until a pair of + 4.50 D. Sph., were before the patient's eyes. These findings indicated a manifest hyperopia of one dioptre and a latent hyperopia of two or more dioptres. The refractive data as secured during the post-refraction on the following day was as follows:

Skiametry Static.

O. U. + 1.00 D. Sph.

Skiametry Dynamic, fixation at 20 inches.

O. U. + 3.00 D. Sph.

The Monocular Cross Cylinder Accommodative Test.

The + 3.00 D. Sph., being left in place was shown to be an over-correction, the test indicating that + 2.00 D. Sph., was all the patient would accept.

Subjective Findings.

O. U. + 1.00 D. Sph.

The Dominant Eye Test.

The Right Eye.

The Determination of the Patient's Visual Working or Near-Point Range.

Average of 15 inches.

Skiametry Dynamic at 15 inches.

O. U. + 3.50 D. Sph.

Near-Point of Accommodation.

12 inches.

Subjective Positive Accommodative Test.

5½ dioptres.

Presbyopic Addition.

In this case, the patient has not the accepted presbyopia, but has however a condition very similar, requiring a correction somewhat stronger for near-point work than that which he will readily accept for distance. The addition is from + 1.00 to + 1.50 D. Sph. The exact amount to be determined later.

Phoria Test, fixation at 20 feet.

1 degree of esophoria.

Phoria Test, fixation at 15 inches.

3½ degrees of exophoria.

Duction Tests, fixation at 20 feet.

O. D. Abd. $7/4$. Add. $24/18$. Infra. $2/1$. Super. $2/1$.

O. S. Abd. $7/3$. Add. $26/18$. Infra. $2/1$. Super. $2/1$.

Duction Tests, fixation at 15 inches.

O. D. Abd. $6/4$. Add. $28/21$. Infra. $2/1$. Super. $2/1$.

O. S. Abd. $6/4$. Add. $28/21$. Infra. $2/1$. Super. $2/1$.

Binocular Accommodative-Convergence Cross Cylinder Test.

This test indicated a near-point correction of + 2.25 D. Sph. With this correction the lines of the crosses were equally indistinct and the crosses were in perfect vertical alignment.

Comment:

This third case illustrates a simple latent hyperopia. The patient's findings indicating that he will accept no more than + 1.00 D. Sph., for distance wear, yet requiring at the same time a pair of + 2.25 D. Sph. for his occupational near-point work. The examiner has several courses of action open to him. He can first, prescribe the + 2.25 D. Sph., explaining to the patient that for a period this correction will naturally cause no little inconvenience and discomfort particularly when the patient is not engaged in near-point work, or he can, second, prescribe two

corrections, or bifocals, a + 1.00 D. Sph., for distance wear and a + 2.25 D. Sph., for near work. The latter method usually gives the greater success as few patients will go through the inconvenience brought on by the resulting fog, as produced when the latent hyperopia is as fully as needed corrected, for constant wear.

Peckham[83] however suggests a somewhat different technic. He believes it advisable to prescribe a bifocal correction, for constant yet temporary wear. His first formula prescribed would be as follows:

O. U. + 1.00 D. Sph. Addition in cement wafer, O. U. + 1.25 D. Sph. () 1 degree Base-in Prism. Peckham does not believe in fogging these cases and suggests the base-in prism wafer to relax the accommodation, suggesting also the use of base-in oculo-prism treatments to further stimulate this relaxation. The advantage of this technic is, he claims, that as the abduction is stimulated by the base-in technic, the accommodation will sufficiently relax to enable the examiner to more fully correct the hyperopia at a distance, and that in a period of several months Peckham claims that he can usually get the patient to accept the full necessary correction of O. U. + 2.25 D. Sph., at a distance, along with a small amount of base-in prism to keep the accommodation relaxed. Peckham uses the bifocal in these cases only as a temporary measure until the patient can accept the full needed correction for distance wear.

Wiseman[84], working along the same theory as Peckham, however, does not find it harmful to fog the patient, his technic in this case calling for a single correction of O. U. + 1.50 D. Sph. () 1 degree base-in prism over each eye, for constant wear, this to be changed as soon as the patient's improved visual acuity permits to a + 1.75 D. Sph. with prism and so on up until the full near-point findings are accepted for distance.

The writer has not had much experience with either of the technics of Peckham or Wiseman and therefore cannot give from actual clinical experience his own results of these technics. Both practitioners, however, do recommend this base-in prism therapy and the entire matter is now being given careful consideration by many practitioners.

Case Four—Simple Hyperopia and Esophoria.

Assuming the findings in this case to be the same as in Case Two with the single exception that the uncorrected phoria test made at the start of the refraction showed four degrees of esophoria present instead of one-half degree as in the three previous cases, and the remaining findings being as follows:

Phoria Test, fixation at 20 feet.

$2\frac{1}{2}$ degrees of esophoria. [The patient being corrected, the esophoria has decreased from 4 to $2\frac{1}{2}$ degrees].

Phoria Test, fixation at 15 inches.
1½ degrees of exophoria.

Duction test, fixation at 20 feet.
O. D. Abd. 4/2. Add. 19/14. Infra. 2/1. Super. 2/1.
O. S. Abd. 4/2. Add. 20/14. Infra. 2/1. Super. 2/1.

Duction test, fixation at 15 inches.
O. D. Abd. 5/2. Add. 20/16. Infra. 3/2. Super. 3/2.
O. S. Abd. 5/2. Add. 20/16. Infra. 3/2. Super. 3/2.

Binocular Accommodative-Convergence Cross Cylinder Test.
+ 1.00 D. Sph.

Comment:

The correction of the hyperopia has materially reduced the esophoria and should be sufficient to enable the patient to carry-on with comfort.

Case Five—Simple Hyperopia and Exophoria, the latter due to a Convergence Insufficiency.

Assuming the findings in this case to be the same as in the preceding case with the one exception that the uncorrected phoria test made at the start of the refraction showed three degrees of exophoria, and the remaining findings being as follows:

Phoria Test, fixation at 20 feet.
3 degrees of exophoria.

Phoria Test, fixation at 15 inches.
9 degrees of exophoria.

Duction Test, fixation at 20 feet.
O. D. Abd. 7/4. Add. 10/6. Infra. 2/1. Super. 2/1.
O. S. Abd. 7/4. Add. 10/6. Infra. 2/1. Super. 2/1.

Duction Test, fixation at 15 inches.
O. D. Abd. 8/4. Add. 10/7. Infra. 2/1. Super. 2/1.
O. S. Abd. 8/4. Add. 10/7. Infra. 2/1. Super. 2/1.

Binocular Accommodative-Convergence Cross Cylinder Test.
+ 1.00 D. Sph.

Comments:

This is a case of simple hyperopia aggrevated by a convergence insufficiency. The writer has found in cases of this type that the correction of the hyperopia is not sufficient to give the patient comfort, he advocating first the removal of the convergence insufficiency by means of oculo-prism treatments[85], technic base-out, and the correction of the hyperopia with lenses in the customary manner.

Case Six—Simple Hyperopia and Exophoria, the latter not due to a Convergence Insufficiency.

Assuming the findings in this case to be exactly the same as in Case Five up to the point of the corrected duction tests, the remaining findings being as follows:

Duction Test, fixation at 20 feet.
O. D. Abd. 12/9. Add. 20/16. Infra. 3/2. Super. 3/2.
O. S. Abd. 12/9. Add. 20/16. Infra, 3/2. Super. 3/2.

Duction Test, fixation at 15 inches.
O. D. Abd. 13/10. Add. 22/16. Infra. 3/2. Super. 3/2.
O. S. Abd. 13/10. Add. 22/16. Infra. 3/2. Super. 3/2.

Binocular Accommodative-Convergence Cross Cylinder Test.
+ 1.00 D. Sph.

Comments:

This case of simple hyperopia is associated with a normal adduction but an abnormal abduction. The correction in the writer's belief which would give the patient greatest comfort in this case would be one incorporating both spherical and prismatic elements as follows:

O. U. + 1.00 D. Sph. () 1½ degrees, Prism, Base-in.

for constant wear. The power of the prism is determined as follows: The abduction is taken. In this case the break came at twelve and the return at nine. One-third of the prism overcome on the return can be safely prescribed base-in in hyperopic cases of this sort.

Case Seven—Latent Hyperopia and Esophoria.

We will now assume that the patient has a latent hyperopia of several dioptres and all of the other refractive findings as in Case Three with the exception that the uncorrected phoria test showed six degrees of esophoria at twenty feet, and the remaining findings from the corrected phoria tests on are as follows:

Phoria Test, fixation 20 feet.
Four degrees of esophoria. [These findings made with a pair of + 1.00 D. Sph., before the patient's eyes. Increasing this to a pair of + 2.25 D. Sph., further reduces the esophoria to three degrees].

Phoria Test, fixation at 15 inches.
1 degree of esophoria.

Duction Test, fixation at 20 feet.
O. D. Abd. 4/2. Add. 24/18. Infra. 2/1. Super. 2/1.
O. S. Abd. 4/2. Add. 26/18. Infra. 2/1. Super. 2/1.

Duction Test, fixation at 15 inches.

O. D. Abd. 5/4. Add. 28/18. Infra. 2/1. Super. 2/1.

O. S. Abd. 5/4. Add. 28/18, Infra. 2/1. Super. 2/1.

Binocular Accommodative-Convergence Cross Cylinder Test.

O. U. 2.25 D. Sph.

Comments:

This case must be so prescribed for in order as to get on the fullest plus correction possible, as previously outlined, and also should have base-in oculo-prism treatments to repress the accommodation. Kurtz[86] cites several cases of this type and others much worse which have been successfully treated by means of this technic.

Case Eight—Latent Hyperopia and Exophoria.

A case of exophoria and latent hyperopia is fully corrected as already outlined by means of base-in prisms and with either two pairs of glasses or bifocals. Base-out oculo-prism treatments should not be given in these cases as the effects of the base-out stimulation would tend to further repress the latent hyperopia.

Case Nine—Latent Hyperopia and Exophoria, the latter caused by a Convergence Insufficiency.

Cases of convergence insufficiency associated with latent hyperopic defects however sometimes must be treated to relieve the convergence insufficiency. In these cases the writer has found it advisable to prescribe both base-out and base-in treatments at the same time, thus stimulating the convergence and the accommodation simultaneously by means of the prism therapy. The writer has also supplemented this technic by means of the fusional development cards of Wells, as well as myoculator training, both of which he has found of value. These latter cases should always have a thorough physical examination, as frequently the convergence reserve is low due to some depletion of the nerve force caused usually by a systemic disorder.

Simple Myopia of Low Degree

The findings in this type of case are not sufficiently different from those of the hyperope to warrant giving complete case reports. The static skiametric findings will in these cases of low myopia be higher in dioptric quantity than the dynamic findings, approximately the same difference being found between the two as in cases of simple hyperopia. Care must be taken however not to confuse these cases of low myopic error with cases of ciliary spasm which frequently accept minus lenses both subjectively and statically, the dynamic findings however in these

cases revealing the true refractive condition. It is well, never to prescribe for myopia irrespective of static or subjective findings if the visual acuity is normal or if the dynamic skiametric findings at the patient's occupational near-point indicates one-half or more dioptres of hyperopia.

Wiseman[87] suggests the use of the following technic in these cases of low myopia, for example, assuming we have a case of one and one-fourth dioptres of myopia. He suggests giving this case an under-correction of say from three-eights to one-half dioptre and also a pair of base-in prisms equal to about three-fourths of the patient's ability to return the two images when the abduction is taken. For instance, if in taking the patient's abduction the break came at ten △ and the return at eight △, his suggestion calls for the examiner prescribing the following corrections: —0.75 D. Sph. () 3 △ base-in, over each eye. This correction materially fogs the patient but the repressing effect of the base-in prism on convergence and accommodation will, he claims, go far towards preventing the case turning into one of progressive myopia and frequently will enable the examiner to remove the minus element from the lenses entirely, as many of his cases have, he claims under this therapy shortly acquired normal vision with the under correction. The same procedure is then repeated, the correction being again reduced, and so on until only the prismatic element is left.

All myopic cases should be constantly under supervision and when the above technic as outlined by Wiseman is employed the need for constant supervision must be fully stressed to the patient.

Latent Myopia of Moderate Degree

These cases differ from those of low degrees of myopia inasmuch as their dynamic findings are frequently at such variance from the static and subjective findings as to make the use of a bifocal correction or two separate corrections imperative. This is an important phase of myopic treatment and one which must not be overlooked. No myope of moderate or high degree should be called upon to do near-point work with a distance correction as this is unquestionably one important factor in producing progressive myopia.

Peckham[88] suggests incorporating base-in prisms in the bifocal wafer, for these cases, the amount of prism to be determined in the same manner as outlined by Wiseman in the preceding paragraph, under the heading of simple myopia of low degree.

Myopia of High Degree

Myopia of from five to twenty dioptres may for general practical purposes be considered dangerously progressive. By this is meant that unless some drastic steps are taken to check its almost always rather

rapid progress, the patient will eventually loose his or her vision. The base-in prism therapy as suggested by both Peckham and Wiseman appeal to the writer as being the first practical attempt made to keep myopes of low and moderate degree from becoming dangerously progressive as prism therapy has a repressing effect, lessening the effort needed to both accommodate and converge, therefore constantly placing the nerve centers and the muscles they innervate in a more favorable position for normal functioning.

In cases which are progressive in character and which require high power minus lenses to correct, Ryer[89] suggests a technic unusual yet seemingly practical and well worth trial. Ryer's suggestion is as follows: "If close work causes progressive myopia in a predisposed case, such myopia may be retarded, if that close work be done with the visual axis parallel and the extrinsic and intrinsic ocular muscles relaxed as in distance vision and close work may be done under these conditions if from the distance correction 3 D. be deducted and to this approximately 18 base-in prism dioptres be added, equally divided between the two eyes.

"To apply these principles to cases of progressive myopia all that is required is comfortable means of holding this lens and prism combination in place and sufficiently strict injunction to insure it being worn and the reading matter being held at the proper range."

Myopia and Exophoria

In exophoric myopic cases the correction of the myopia itself will as a rule relieve the exophoria. Oculo-prism base-out treatments must never be prescribed in these cases as the application of these treatments will tend to increase the amount of myopia present.

Myopia and Esophoria

In these cases base-in oculo-prism treatments together with the correction of the myopia must be prescribed, providing of course that the case is one of true myopia itself and not one of ciliary spasm, as is frequently found where low amounts of myopia are suspected.

In myopia as in hyperopia the full astigmatic findings should always be prescribed, the writer urging examiners to follow as nearly as possible the findings of the ophthalmometer.

The following pages give a short review and again show the sequence of a routine refraction, as previously outlined, illustrating just what data are necessary to be recorded to enable the examiner to satisfactorily diagnose and prescribe for the refractive and muscular defects of each case.

Patient ....Case No................
Address .... Date..........................

Case History

Occupation....................... Age..... Speaks...............only
Nationality....................... Place of Birth....................
Data regarding parent's vision..
Health and vision during childhood........Measles....Scarlatina......
Condition of eyes at start of school..................................
Accidents or diseases relating to eyes......Catarrhal Conjunctivitis......
Age at start of wearing glasses......Number of years glasses worn......
Do your eyes disturb your distance vision.........Near vision.........
....
Onset: Thinks present trouble began about..years..months..weeks..ago
At what distance do you do your work..........Hold your reading......
Posture while at work...
Light conditions while at work.........Effect of artificial light..........
Do you become drowsy while doing close work.......Type blur........
Have you headaches...............Suffer from asthenopia..............
Location of headaches: Frontal..Temporal..Vertex..Orbital..Occipital..
Type of headaches: Dull........Constrictive..........Pulsating........
Time headaches occur: A. M...P. M...After close work..After cinema..
Do you now or have you ever suffered from squint..When first noticed...
Was the squint occasional....Periodic....Permanent....Nystagmus....
Do you suffer from nausea or dizziness at home......While on cars......
Subject to Granular Lids....Inflamed Conjunctiva....Hordeolums......
Subject to Epiphora....Diplopia...Photophobia...Muscae Volitantes....
Condition of Ears.................Condition of teeth...............
Condition of Nose.....Nasal Catarrh.....Sinus Trouble.....Asthma....
Condition of Throat.........Bronchial Catarrh........Tonsillitis.......
Condition of Stomach.............Condition of Nerves................
Condition of General Health...
....
....
At present time under the care of Dr...........for...................
Patient referred by Dr...........Patient referred by M...............
Data regarding appetite..........Regarding food consumption...........
Regarding rest...........Regarding bathing..........................
Regarding exercise...............Regarding excretion...............
Regarding the use of stimulants, with the approximate amount used per day
Tea....... Coffee....... Tobacco .... Alcohol.......Drugs.......
Patient's height..Patient's stature: Emaciated....Normal....Obese......
Patient's apparent mental attitude: Nervous....Normal..Phlegmatic....

Patient's apparent health: Weak and tired......Active and strong.......
Patient's complexion: Light..Dark..Patient's hair: Blond.Blunette.Gray.
Condition of Patient's skin..........Breath..........Oral cavity........

Previous Distance Correction

In use............years Prescribed by Dr..............
O. D......... Sph......... Cyl. Axis......()...... Prism, Base........
O. S......... Sph......... Cyl. Axis......()...... Prism, Base........
Bifocal Type....Addition, O. D....O. S..... Visual Acuity, O. D..O. S..

Visual Acuity Uncorrected

Acuity taken with Standard Test Type.........O. D....O. S....O. U....
Acuity taken with..........Test Type.........O. D....O. S....O. U....
Acuity taken with Numeral Test Figures.......O. D....O. S....O. U....
Acuity taken with Kindergarten Test Figures...O. D....O. S....O. U....
Acuity taken with Pin Hole Disc..............O. D....O. S....O. U....
Acuity taken with Stenopaic Slit.............O. D....O. S....O. U....
Acuity taken with Finger or Hand Test at.c/m. O. D....O. S....O. U....
Acuity taken with Ivory Ball Set.............O. D....O. S....O. U....
Acuity taken with Light and Dark Test.......O. D....O. S....O. U....

The Cover Test

O. D. ....O. S. ....

Uncorrected Phoria Test

Esophoria......................... Exophoria.........................

Versions

O. D.................. O. S.................O. U.................

External Ocular Inspection

General appearance of Eyes.....................Orbits................
Position of Eyeball; Deepseated......Normal......Protruding.........
Cover Test...Strabismus, O. D....O. S....Strabismometry, O. D..O. S..
Nystagmus ....
Eyeball; Size....Lack of symmetry....Intraocular Tension, O. D..O. S..
Lids; Palpebral Fissure...Ability to move, O. D.........O. S.........
Blepharospasm........Ptosis........ Ectropion........ Entropion......
Condition of Skin covering........Herdeolums......Chalazion.........
Condition of Lid Edges....Granulations..Ulcerations..Scabs..Puncta...

Condition of Lashes............Number............Ptilosis............
Region of Lacrymal Sac..........Buldging........Excretions..........
Conjunctiva of the Lid and Fornix....Transparency....Thickening......
Color................. Surface................. Scars.................
Bulbar Conjunctiva......Transparency.....Thickening....Color........
Ecchymosis, O. D......O. S....... Pterygium, O. D....... O. S.......
Sclera............................. Stained......... Clear............
Cornea; Size......... Form............ Arcus Senilis................
Condition of Epithelium............Opacities........ Scars............
Transparency...... Inflammation...... Ulceration...... Reflexes.......
Vascularization............ Sensitiveness......... Foreign Bodies.......
Anterior Chamber...... Depth....... Clearness......... Contents......
Lens; Present........ Absent........ Position.......... Color.........
Iris; Position............ Color, O. D................. O. S...........
Malformations......................... Adhesions.......................
Pupil; Size, O. D....m/m., O. S....m/m. Shape........Position.......
Response to Light, O. D....O. S..... Response to Accommodation......
Data on Previous Ocular Surgery.....................................

Ophthalmoscopic Examination

Oblique Illumination. O. D. Sketch of Apacities O. S.
Condition of Anterior Chamber..........
Condition of Iris.........................
Condition of Posterior Chamber.........
Condition of Lens.......................
Condition of Vitreous..................
Fundus Notation—Right Eye

Fundus Notation. Right Eye.

The disc is $\left\{\begin{array}{l}\text{round}\\\text{oval}\\\text{elliptical}\end{array}\right\}$ in shape, $\left\{\begin{array}{l}\text{pale}\\\text{medium}\\\text{dark}\end{array}\right\}$ rose reddish in color, with a $\left\{\begin{array}{l}\text{broad}\\\text{medium}\\\text{narrow}\end{array}\right\}\left\{\begin{array}{l}\text{clearly}\\\text{average}\\\text{poorly}\end{array}\right\}$ defined edge, the tendency being to merge off towards the $\left\{\begin{array}{l}\text{nasal}\\\text{temporal}\end{array}\right\}$ side. The cup is $\left\{\begin{array}{l}\text{small}\\\text{moderate}\\\text{large}\end{array}\right\}$, it being $\left\{\begin{array}{l}\text{easy}\\\text{difficult}\end{array}\right\}$ to see, and is $\left\{\begin{array}{l}\text{very deep}\\\text{average}\\\text{shallow}\end{array}\right\}$. The choroidal ring shows $\left\{\begin{array}{l}\text{very strongly}\\\text{clearly}\\\text{faintly}\end{array}\right\}$ on the $\left\{\begin{array}{l}\text{nasal}\\\text{temporal}\end{array}\right\}$ side, with the scleral ring showing at

the........................ The vessels are approximately..........
in number, their course being......................................, and
their pulsation quite {moderate / marked}. The macular region is rather {easy / difficult}
to discern, the general color being a {pale / medium / dark} reddish, with {one / no}
{small / medium / large}, bright foveal dot being visible. The general fundus color
is of the {feeble / moderate / pronounced} {blonde / brunette} type. The outstanding features of this
fundus being as follows..................and have been sketched above.

Fundus Notation—Left Eye

The disc is {round / oval / elliptical} in shape, {pale / medium / dark} rose reddish in color,
with a {broad / medium / narrow} {clearly / average / poorly} defined edge, the tendency being to merge
off towards the {nasal / temporal} side. The cup is {small / moderate / large}, it being
{easy / difficult} to see, and is {very deep / average / shallow}. The choroidal ring shows
{very strongly / clearly / faintly} on the {nasal / temporal} side, with the scleral ring showing at
the........................ The vessels are approximately...........
in number, their course being......................................, and
their pulsation quite {moderate / marked}. The macular region is rather {easy / difficult}
to discern, the general color being a {pale / medium / dark} reddish, with {one / no}
{small / medium / large}, bright foveal dot being visible. The general fundus color

is of the $\left\{\begin{array}{l}\text{feeble}\\ \text{moderate}\\ \text{pronounced}\end{array}\right\} \left\{\begin{array}{l}\text{blonde}\\ \text{brunette}\end{array}\right\}$ type. The outstanding features of this fundus being as follows.................. and have been sketched above.

Sphygmomanometer Findings

Systolic................ Diastolic................ Pulse Pressure.......
Result.. Time taken...........

Transillumination

O. D...
O. S...

Color Vision

Technic employed...
O. D...
O. S...

Perimetry and Campimetry

Charting the peripheral field, using perimeter in Artificial....Daylight....
Technique; Visible to Invisible..........Invisible to Visible............
Irregularities of field of vision, using the McHardy Perimeter
O. D...
O. S...
Apertures used; 10-5-3-1. See attached perimeter charts...............
Charting the central area, in Artificial............Daylight...........
Technique; Visible to Invisible...........Invisible to Visible..........
Irregularities of the central field, using the Stereo-Campimeter.
O. D...
O. S...
Test Objects used; 05-1-2-3-4. See attached Lloyd charts...............

Ophthalmometric Findings

O. D. Meridian Measured..................Dioptic Power..............
Meridian Measured..................Dioptic Power..............
Resultant Corneal Astigmatism.........Dioptres, Axis...........
O. S. Meridian Measured..................Dioptic Power..............
Meridian Measured..................Dioptic Power..............
Meridian Corneal Astigmatism.........Dioptres, Axis............
Radius of Cornea in m/m with the Universal Ophthalmometer in secondary position when no astigmatism has been registered; O. D..... O. S....

Skiametry, Static

Operating Distance............ Reflex..............
O. D................ Sph................ Cyl. Axis................
O. S................ Sph................ Cyl. Axis................

The First Dynamic Skiametric Check Test

Fixation at................. Reflex..............
O. D................ Sph................ Cyl. Axis................
O. S................ Sph................ Cyl. Axis................

The Post Refraction

Skiametry, Static

Operating Distance.................. Reflex...........
O. D................ Sph................ Cyl. Axis................
O. S................ Sph................ Cyl. Axis................

The Second Dynamic Skiametric Check Test

Operating Distance.................. Reflex...........
O. D................ Sph................ Cyl. Axis................
O. S................ Sph................ Cyl. Axis................

Monocular Cross Cylinder Accommodation Test

Fixation Distance...........Cross Cylinder used.....................
O. D..
O. S..

The Corrected Subjective Distance Acuity of Vision Test

O. D.........Sph.........Cyl. Axis.........Visual Acuity, 20/.........
O. S.........Sph.........Cyl. Axis.........Visual Acuity, 20/.........

Dominant Eye Test

O. D............................ O. S..............................

Distance Comparison Test

Results: O. D...................... O. S..............................

Determination of the Patient's Visual Working Range

Patient habitually holds reading matter at, from.......to...........c/m
Patient's clerical work requires a near-point focus of, from.....to....c/m.

Patient's mechanical work requires a near-point focus of, from..to..c/m.
For Music, Patient requires a near-point focus of, from.....to.....c/m

The Third Dynamic Skiametric Check Test

Fixation at the Reading distance of...............c/m.
O. D................. Sph................. Cyl. Axis.................
O. S................. Sph................. Cyl. Axis.................
Fixation at the Clerical Working Distance of..........c/m.
O. D................. Sph................. Cyl. Axis.................
O. S................. Sph................. Cyl. Axis.................
Fixation at the Mechanical Working Distance of............c/m.
O. D................. Sph................. Cyl. Axis.................
O. S................. Sph................. Cyl. Axis.................
Fixation at the Music Rack Distance of............c/m.
O. D................. Sph................. Cyl. Axis.................
O. S................. Sph................. Cyl. Axis.................

Near-Point of Accommodation

O. D............................. O. S...............................

Subjective Positive Accommodative Test

Amplitude; O. D...............O. S...............O. U...............
Oculo-Dynamic Treatment prescribed for O. D.....O. S.....O. U.....
Patient to return in....weeks after exercising Ciliary.....times a day

Subjective Near-Point Addition

Add to Distance correction as follows for Reading:
O. D......Sph. O. S......Sph. Comparison Test; O. D......O. S......
Range of Vision with addition, O. U....to....c/m. (App. or with Tape)
Add to Distance correction as follows for Clerical Work:
O. D......Sph. O. S......Sph. Comparison Test; O. D......O. S......
Range of Vision with addition, O. U....to....c/m. (App. or with Tape)
Add to Distance correction as follows for Mechanical Work:
O. D......Sph. O. S......Sph. Comparison Test; O. D......O. S......
Range of Vision with addition, O. U....to....c/m. (App. or with Tape)
Add to Distance correction as follows for focus at the Music Rack distance:
O. D......Sph. O. S......Sph. Comparison Test; O. D......O. S......
Range of Vision with addition, O. U....to....c/m. (App. or with Tape)

Corrected Distance Phoria Tests

Esophoria.....Exophoria.....R. Hyperphoria.....L. Hyperphoria.....

Corrected Near-Point Phoria Tests

Esophoria......Exophoria.....R. Hyperphoria.....L. Hyperphoria.....

Distance Duction Tests

O. D. Abd...../...... Add...../..... Infra..../.... Super..../....
O. S. Abd...../..... Add...../..... Infra..../.... Super..../....

Near-Point Duction Tests

O. D. Abd...../...... Add...../..... Infra..../.... Super..../....
O. S. Abd...../..... Add...../..... Infra..../.... Super..../....

The Binocular Accommodative-Convergence Cross Cylinder Test.

Fixation Distance............ Cross Cylinder used......................
O. D................................O. S...............................

Diagnosis

Sketch ....
....
....
....

Signed Dr..........Refracting Optometrist
Signed Dr...........Consulting Optometrist

Initial Formula Prescribed

Date.......................................
To be used as a Distance Correction......or as Suppression Lenses......
O. D..........Sph..........Cyl. Axis..........Prism, Base..........
O. S..........Sph..........Cyl. Axis..........Prism, Base..........
Reading Correction....Clerical Work....Mechanical Work....Music....
O. D..........Sph..........Cyl. Axis..........Prism, Base..........
O. S..........Sph..........Cyl. Axis..........Prism, Base..........

Prognosis

. ...
. ...
. ...

Initial Instructions to Patient

. ...

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. ...

Patient to return for a Post-Refraction, Day......Date......at......M.

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SOME TYPES OF BINOCULAR IMBALANCE

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Perfect binocular functioning is the result of perfectly co-ordinated innervational control of the associated action of all the extrinsic and intrinsic muscles of the two eyes. Imperfect co-ordination, causing imbalances, may arise from many sources, have many different origins.

There is the exertion made by some individuals to compensate for structural hyperopia, producing a hyper-tonicity, even a hypertrophy, of the extrinsic muscles used in convergence and of the circular fibers of the ciliary muscles. Then we have that so called heterophoria denominated esophoria. In later years, because of this supreme effort, exhaustion appears and we have exophoria at the reading point. Often, usually in fact, these esophores show esophoria in the morning when they are fresh and rested and exophoria at evening when they are tired.

There is also an esophoria in young women that is not connected with latent hyperopia but is a symptom of psychopathic disturbance.

There is an esophoria following the mumps, in adults, due to carelessness, either on the part of the physician or the patient, that is a symptom of disturbance in the sexual organism.

There is an exophoria in elderly people that is a symptom of lack of exercise, improper diet, low body tonicity.

There is an exophoria in growing boys, due to imbalances in the endocrine glands.

There is an exophoria accompanying immaturity, or arrested development, of the convergence-accommodation function.

There are sundry esophorias, exophorias and hyperphorias because of impaired conductivity of the motor nerve fibers, due to toxemias.

There are hyperphorias caused by the efforts of the central nervous system to use the convergence-accommodation function that are only evidencies of misdirected, or improperly conducted, motor impulses.

Manifest hyperopia is a symptom of imbalance. And there are two types of manifest hyperopia, if we are to use our skiascopes rather than our subjective tests in measuring apparent defects. One is to be corrected by plus lenses, the other is not to be so corrected.

Myopia is a symptom of imbalance. Not a sign of imbalance in the convergence-accommodation functions, but a sign of imbalance in the vital organs of the body.

Digestive disturbances cause imbalances. Mental disturbances, worry, fatigue, repression of desire, fear, anxiety, all these cause disturbances in motor innervational routes, giving the appearance of imbalances.

All these we have classed under the general term of "muscle troubles," or "muscle imbalances." They have been incorrectly named "heterophorias." But the fault lies not in the muscle but in the source and method of its control.

We have sought to correct these imbalances optically, by giving prisms in the incorrectly named "position of rest," thinking that by displacing the image to the macula, which is evidently not held in its proper place during the phoria test, that we would alleviate the sufferings of our patients.

But there is no such thing as a prism "in position of rest." Wherever a prism is placed, no matter in what position before the eyes, it is in a "position of exercise." The eye must always turn toward the apex of the prism in order to place the fovea beneath the image. The muscle beneath the apex must always be innervated, or flexed. The muscle beneath the prism base must always be inhibited, or lengthened.

For the eyes in use are not in the position in which they are found during the phoria test, excepting in cases of dynamic orthophoria. And when we put a prism in front of an eye that will displace the image to the fovea in that position, we compel the central nervous system to so arrange the innervations and inhibitions of the extrinsic muscles that the eyeball may be held permanently in that position. The result, as we have learned, is that the manifest imbalance seems to grow greater.

Optical treatment of these manifest imbalances is a failure. For the problem is not optical, it is physiological. So long as we practice refraction as a purely optical problem, so long as we neglect the study of physiological functions, we fail in our purpose, which is to bring comfort to an uncomfortable pair of eyes.

In general, we have been considering these imbalances as causes rather than as symptoms. We have been trying to treat symptoms instead of striving to learn the cause behind the symptom. We have, mistakenly, considered that a manifest esophoria or a manifest exophoria is the cause of the distress of which the patient complains. But the esophoria is not the cause of discomfort, neither is the exophoria. These are but symptoms. Find that which caused the esophoria, the disturbance that lies behind the exophoria, remove that cause and the discomfort is removed. With the discomfort gone, the manifest symptom also disappears, because its cause has been removed. We must cease treating symptoms, we must search for the cause of the symptom.

When these heterophorias were first discovered, when they were first studied, it was thought that they were structural in origin. We offer no criticism of those earlier workers, for the physiological knowledge

we possess today was then lacking. These earlier workers did exactly what they should have done, proceeded to dissect and examine the structure of the muscles. And when they found that the inturning muscles of the known esophore were shorter and heavier than those of the known orthophore and exophore, when they found that the inturning muscles of the known exophore were longer than those of the known orthophore, they concluded, on the evidence, that the error was structural. But they did not appreciate that muscle structure is a development of use, that what we find in the adult is no indication of his congenital structure.

But these true students could not live forever. Most unfortunately, they were succeeded by a group of purely speculative writers. These evolved theories, apparently out of thin air, for there is no evidence of actual research work behind their postulates. The search for answers to the problems presented to the refractionist in his work developed into a guessing contest, with the honors to him who could use the most fluent language, evolve the most abstruse terms, hide his paucity of thought in the most pseudo-technical jumble of words. With a supreme disdain of the few facts we have, with an exalted indifference to our lack of facts, theory has been piled on theory, until we are completely lost in a cloud of nothingness.

So we have thrust upon us a vocabulary of terms whose validity we may fairly doubt. It seems probable that these terms describe some phase or condition that is purely hypothetical rather than actual. We have the mistaken teaching that esophoria is "convergence excess," that exophoria is "convergence insufficiancy," ideas that do not harmonize with provable facts. We have such meaningless terms as "fusional reserve;" "convergence reserve;" "lag of accommodation;" "amplitude of relative accommodation;" "physiological exophoria;" "fatigue fields," "fatigue points," as indicated in the duction tests; "suspenopsia;" "accommodative convergence;" "fusional areas of the retinae;" "fusion faculty;" "accommodative exophoria;" "fusion convergence;" "supplemental convergence;" "supplemental divergence;" and so on, interminably; weird terms, that will not stand critical investigation under laboratory methods; that do not agree with what we can safely feel we know about physiological functions. The authors of these terms cannot express intelligibly their conceptions of these terms, since their theories are based on abstract reasoning, rather than on actual work.

We have very few facts. There is almost nothing surely known about the functions of the eyes. We know almost nothing about the pathways by which innervations reach the ocular muscles. We are completely at loss in understanding just how mental psychoses affect functions. We cannot trace the pathways by which disturbances in the vital organs reach the ocular muscles and throw them out of balanced co-

ordination. We do not know how it is that the efforts at clear vision made by the hyperope disturb the digestion, the circulation of the blood, the heart beat.

But in the past few years we have learned a few things. And for these things our thanks are not due to research men in either optometry or ophthalmology, for of these there are none. Our gratitude must be given to the physiologists and a few physicists, who searching for explanations of affairs in their own field have unearthed a wealth of data which concerns our work. We must go to their writings, not to those of our own men, for information.

I do not wish to waste your time in speculative discussion. We have all had too much of that in the past. We shall have to give a little time to the study of causes, so far as we know them, in order to appreciate the methods by which we may alleviate the discomforts of some of our patients.

I do not want you to think for a moment that the ideas or methods here presented are entirely of my own devising. For no one man could cover the ground that our group of co-workers has gone over in the past six years. Mine has been merely the happy task of drawing this group together, of assisting in the collaborations of results, in bringing many products from many diverse sources, of attempting to co-ordinate these into usable working procedures.

Nor would I have you think that any of us believe we have arrived at any ultimate truth. We know full well that we have hardly started, that there is less of the known than of the unknown. What I tell you here is subject to revision, possibly some of it to complete contradiction, as we learn more.

Some of these methods have been derived from laboratory research, ever far more satisfactory than what we observe in office practice. All have been subjected to the test of time. We feel that all are based on sound physiological principles, so far as the physiological and nervous anatomy are known.

One of the drawbacks to the treatment of cases is that we are not always able to follow up the case long enough to know exactly what happens. Many a man has thought he had solved the problem of a difficult case because the patient for whom he prescribed the lenses did not return to report difficulties. A good many times he has written a case report for our journals describing the successful handling of a case when, in reality, the patient was not helped but did not return to him with complaint. So we cannot safely say that a method is good or successful unless we have the patient under observation for several years. I shall not fall into this error in describing the methods we have found satisfactory.

We have learned one thing. That because a given case is solved by one method, that comfort has been brought to the patient by a certain treatment, that the same treatment will not necessarily give relief to another patient who, at first glance, presents the same general symptoms. We have not developed the habit of looking for the little things, the apparently minor symptoms, that will distinguish this case from all other cases. Our methods of diagnosis are not sufficiently painstaking, our office equipment too meager, our education in physiological functions too limited, we fail to differentiate symptoms.

We must learn to be more discriminating. We must learn to find all the symptoms, to differentiate between cases that at first glance seem alike. One of the difficulties in presenting a paper like this is the fear that the reader will conclude that every case in a general class will be benefited by the treatments described. In this limited time we cannot hope to cover but a few of the more common types of imbalances and discuss general principles. So let us consider this warning carefully, that every case presents some feature that distinguishes it from every other case and all treatment methods must be modified to suit that particular case.

Convergence-Accommodation

We have talked and written a great deal about accommodation, without in the least appreciating what it is. We have talked about convergence, without realizing what a simple thing it is, merely the direct reflex of the two images falling on the temporal sides of the two foveas, simply the subconscious turning of the foveas to their position beneath the two images.

We have had a great deal of vague writing about the associations of convergence and accommodation, vague because the writer's ideas were vague and speculative. These writings have been a hindrance rather than a help.

Because focussing seemed the chief requirement of vision, and without doubt it is, we have been prone to ascribe undue powers and authority to the function of accommodation. Because we have noted that often a forcing of accommodation has been accompanied by a forcing of convergence, because we have seen that frequently repression of the accommodation is accompanied by repression of convergence, we have assumed, without other reason than the mere observation, that accommodation controls convergence. From mere observation we can just as easily assume the reverse, that convergence controls accommodation. The answer is not to be thus found. We must study the fiber tracts of the brain, physiological functions, biology, before we can safely assume anything.

Physiologists tell us there is a function that we have not considered, a function of convergence-accommodation. An independent function, complete in itself, an entity, more than the mere association of two independent functions more or less loosely associated.

And we note that it is called "convergence-accommodation," instead of the term we have been using, "accommodative convergence." The stress and the importance are put on the convergence.

And, they say, this is the function that we humans call into activity when our interest is aroused in an object that we wish to see clearly. Convergence-accommodation is an "attention reflex," involves the psychic factor of mental interest. Convergence-accommodation is a learned reflex, control of muscles accomplished by experience and practice, not an innate function.

Some learn to use this function successfully. Some fail. Their success or non-success depends entirely on their interest in the object at which they look.

We have not the time to discuss this further. It is a subject of vast importance. For its understanding we must study the laws of muscle control, of the reflex arc. This we must omit, here, and go on to some of the practical applications.

Emmetropia

The definition of emmetropia, as we have understood it, is such a perfection of anatomical structure that when the attention is fixed on a far distant object, with the accommodation completely relaxed, rays of light from that object focus exactly in the retina. Practically, we say an eye is emmetropic when its vision is normal at 20 feet and a weak plus sphere or a weak minus sphere blurs the vision.

But we cannot find any such structurally perfect eyes. For the definition says, "with accommodation completely relaxed." When we put atropine into an apparently emmetropic eye, we find that the accommodation can be further relaxed, that is, hyperopic anywhere from half a dioptre up to two or three dioptres, sometimes even more.

Every emmetrope is a latent hyperope. He has compensated a certain amount of structural hyperopia. He has done this because of his interest in the things about him. He has done this by the use of the convergence-accommodation function.

We are all born hyperopes, if we are healthy. Myopic babies are diseased babies. That much we can be sure of. We are all born exoptropes. After birth we learn, slowly, to use our two eyes together, to turn them inward toward the object we are interested in. So we learn to use our convergence-accommodation. Usually it takes us from ten to twelve years to get it into good working operation. Some of us are precocious, learn the trick by the time we are six or seven years old.

Many of those precocious youngsters, we find by watching their development, become esophores. Some of us never learn the completely successful use of our convergence-accommodation.

Small children are not emmetropic. Normally they have considerable manifest hyperopia under the skiascopic test. But plus lenses do not clear their vision. We shall return to this later.

We shall, then, look at emmetropia, not as a structural condition of the eyeball, but as a dynamic condition, representing the successful arrival at focus by the use of the convergence-accommodation function, incited by interest in environment.

Manifest Hyperopia

What we consider as manifest hyperopia is a condition where the images are focussed behind the retina and plus lenses, by bringing the images forward to the tips of the cones puts them into focus, makes objects more clearly visible.

The manifest hyperope is one who has not learned to use his convergence-accommodation to the full limit of its possibilities. Why?

Consider some of the young men or women who come into your office complaining that the eyes tire under the strain of constant near work. They say they do not need distance glasses, they can "see well enough." But your test shows that they have only 20/XXX or 20/XL letter vision at six meters. You tell them they do not see well at distance. They contradict you, insist that they see well.

Hand them a newspaper or a picture, to test the near vision. They see the print, the details of the picture perfectly well. They make the effort to see it. They do not make the effort to see clearly at distance.

Now there is a surprising thing about these persons. The degree of the sharpness of their distant vision depends on the object they look at. Their sharpness of vision varies under different tests with different objects. It all depends on how much they are interested in the object.

Psychologists tell us that all our muscular efforts are based on our need, or desire, to put ourselves in harmony with our environment. We make that effort, and no more, that makes us feel contented, complacent.

The manifest hyperope who does not see clearly, but says he does, is one who uses just enough convergence-accommodation to satisfy himself. The moment he realizes he does not see clearly enough, he satisfies his discontent by obtaining a pair of lenses that will give him clear vision. If his eyes hurt under the strain of driving the convergence-accommodation to clear vision, at either distance or near, he seeks to rid himself of his discomfort by visiting the optometrist.

The little boy or girl who is curious, investigative, who wants to know all about everything about him, learns that by using his convergence-accommodation he can overcome his structural hyperopia and

see clearly. So they do not wait until the eyeball develops to its adult size along with the development of the rest of the body. They make themselves dynamically emmetropic by an effort of the convergence-accommodation, arrive at the point of 20/XX or 20/XV vision when they are only six or seven years old.

Esophoria with Latent Hyperopia

Dissection shows that in the known esophore the convergence muscles are comparatively thick, short, well developed. While their antagonists, the external recti, are correspondingly long, thin, not so heavily developed. Also, the circular fibers of the ciliary muscles are heavy, while their antagonists, the radial fibers are few, thin, hard to find. At first, this was thought to be congenital structure, but now we realize that muscle development is a matter of use. Muscles that are continually in use are well developed, muscles that are unused are flabby, weak.

Muscles are arranged in antagonistic pairs or antagonistic groups. When one is contracted, or flexed, its antagonist must lengthen. We say, when we shorten a muscle, that we innervate it, for to shorten a muscle we must send an innervational motor impulse into it. When we lengthen a muscle, we say we inhibit it, for we must withdraw the innervational impulse from it.

Then every act involves the innervation of some muscles and the inhibition of their opponents. These innervations and inhibitions must be properly balanced or the act will not be successful. These balanced innervations and inhibitions are called reciprocal innervations.

Tonicity is a function of the nervous system by which the muscles are kept in preparation for action. But when a muscle is contracted by an innervational impulse an additional flow of tonicity is sent to it to prevent if from becoming fatigued, to keep the fluid content of the muscle in a neutral chemical condition so that its cells are rebuilt, as their walls are worn down during activity and must be continually repaired. During contraction, the fluid content of the muscle becomes acid, lactic acid is formed. This acid must be neutralized, or the muscle cells cannot be rebuilt. It is one of the functions of tonicity to neutralize this lactic acid. The lactic acid is a residuum left in the blood stream after the muscle cells have drawn out the chemicals needed for rebuilding.

Now when these tonicity impulses are sent to a muscle that is in action, an equal amount of tonicity is withdrawn from the opposing muscle. When a muscle is kept continually contracted, as the extrinsic converging muscles and the intrinsic circular fibers are kept by the esophore, the opposing muscles, in this case the external recti and the radial fibers of the ciliary, the contracting muscles are kept in a continual high state of tonicity, the lengthened opponents are kept in a continued state of low tonicity.

When a muscle contracts it shortens and thickens. That is because each individual cell of each muscle fiber is forced, by the innervational impulse, into a less oval, more nearly rounded shape that is its form when the muscle is not working. When the muscle is lengthened, or inhibited, the cells are elongated. That is the reason the muscle shortens and thickens when it is flexed, why it grows longer and thinner when its innervation is withdrawn.

Continued contraction of a muscle, with continued tonicity supply, results in its permanent shortening and thickening. Continued inhibition of a muscle with continued reduction of tonicity supply results in the permanent lengthening and thinning of the muscle. That is why, on dissection, the converging muscles of the esophore, and circular fibers of the ciliary, are found apparently short and heavy; why the external recti and the radial fibers of the ciliary are found apparently longer and thinner. Also, and fully as important, continued use of a muscle results in its development, sometimes to a comparative hypertrophy. Continued non-use of a muscle results in its wearing away, apparent semi-atrophy. The continually used muscle is really in a state of hyper-tonicity while its continually non-used, or little used, opponent, is in a state of hypo-tonicity, or lowered tonicity.

When we make the phoria test and find esophoria, the muscles have not "assumed their position of rest," but a posture indicative of the hyper-tonicity of the inturning muscles and the hypo-tonicity of their opponents.

The original definition of esophoria says that the visual axes swing inward when the muscles assume their position of rest. This definition stands, if we change the last phrase. That is erroneous, for the muscles assume the position showing the comparative tonicity of the two groups of antagonists.

Exophoria

In saying we find exophoria, we mean a manifest exophoria. For there is a latent exophoria just as there is a latent hyperopia. We often say a man has 1 D. or 2 D. of hyperopia, when we really mean he has that much manifest hyperopia. In reality, he has more hyperopia than this, but that part is held latent by the activity of the convergence-accommodation function. The same is true of the latent exophoria. We all have some latent exophoria, which is the difference between the structural position of our eyes, as they lie in the orbits, and the position of the visual axes when we are looking at an object with both eyes.

We may say, in general terms, that a manifest exophoria represents a low tonicity of the convergence muscles, so that when the impulse to turn both maculae at the same time to both images is made impossible, the eyeballs tend to return to their structural position, which is one of exotropia.

We might say, from a priori reasoning, that innervation is withdrawn that the convergence muscles may rest, but this would be too speculative. It is, however, a fit subject for laboratory research.

There is one type of exophoria that represents exhaustion. The esophore of the forenoon is often an exophore late in the afternoon. This is quite common among esophores of middle age. With an uncorrected hyperopia, which they compensate with an effort of the convergence-accommodation; because of advancing age with its general reduction of body tonicity; perhaps, also, having improper diet habit; the day's labor leaving them "tired all over;" to which labor must be added the work of compensating the hyperopia; the close of the day finds him ready to relax, he is exophoric. Yet after a night's rest, we find him once more esophoric. This exophoria, as well as the esophoria, vanish when we give him the needed plus lenses.

Similar to this is the case of the man with esophoria at distance and a high exophoria at near. The exophoria is indicative of exhaustion. Provide the needed plus lenses and it disappears.

Elderly people usually show high exophoria at both distance and near. This is because of low body tonicity. Advancing age and lack of exercise are responsible. When this low tonicity becomes troublesome in the effort at reading, it seems as though we might as well provide some base-in prism, to lessen their effort. But this only applies to people so old that we cannot hope to bring up tonicity by exercise. But remember this, it is not the exophoria that causes the trouble. The trouble is due to lack of tonicity, and this is the cause of the appearance of the exophoria.

There is one odd type among these cases. Take a ordinary stereoscope, on a card of the right size to fit it draw two circles, their centers about 63 mm. apart. In the centers of these circlee, which may be from 20 to 30 mm. in diameter, draw two short upright lines. Now with this card in the stereoscope the two drawings should fuse into one. But now and then we shall find an elderly person, once in awhile one not so very old, who will fuse the circles but will see two lines. Just what these people do when they read, I do not know. Whether they actually fuse the letters of the words they read, or alternate their fixation, I do not know. I should call this exophoria a "convergence insufficiency." But the exophoria in itself is not convergence insufficiency, nor is the insufficiency due to the exophoria. Both are merely symptoms. I think this agrees with what Professor Ames calls "Foveal Slip," a subject of considerable interest about which nothing is known.

It is too bad that exophoria was, in the early days, considered "convergence insufficiency." This false idea still prevails, will take many years to obliterate. It has led to many misconceptions and wrong methods of treatment.

Among people of sedentary habits, from 40 to 60 years of age, we often find considerable exophoria. This, again, is a sign of low body tonicity, from lack of exercise and, too often, improper diet. This type of exophoria seems on the increase in this day when there are so many mechanical devices that prevent us from working. The best cure for this exophoria is general body exercise. Send a man with 15 △ of exophoria to the gymnasium three or four days a week and his exophoria will take care of itself.

It is justifiable, when we cannot get the patient to take the needed exercise, to give base-out prism exercises. Now what do these do? They exercise the convergence muscles, build up their tonicity, make them shorter. But this is only temporary. We have not helped the patient because we decreased his exophoria. We have helped him because we started the flow of tonicity to the convergence muscles. The decrease of the exophoria is a mere co-incidence. After a few weeks, the spur to tonicity is gone, the discomfort at reading returns, so does the exophoria. These people are not uncomfortable because they have an exophoria. They are uncomfortable because they do not exercise enough.

There is an exophoria that goes with acidity of the stomach. There is also an esophoria from the same cause. It seems to be largely a matter of degree. No prism wearing or prism exercises or lenses will help these people. They are to be turned over to a diet specialist and put on an alkaline diet. The apparent ocular imbalances will then disappear.

Sometimes a boy of 16 to 18 will come in complaining that his headaches when he studies. The most careful examination will reveal nothing but a very high exophoria. I have seen this as high as 20 △ at distance, as high as 35 △ at near. You can crowd on + 0.50 for reading, but it does not help him, it blurs his distance vision and never clears up. This exophoria, and the headache, we find, is one of the symptoms of a delayed absorption of the thymus gland, with resultant dysfunction of the thyroid and pituitary. Turn the boy over to the endocrinologist, or to a good neurologist. He will locate the trouble, give the boy proper treatment and his headache and exophoria will disappear.

Considerable exophoria is generally found with manifest hyperopia with astigmatism. Refract the case accurately and the exophoria decreases. This is of afferent origin, a poor motor stimulation because of a poor sensory stimulus. Give the sharp image, the sharp sensory stimulus, the motor response will then be quick and sharp, tonicity will develop, the exophoria decrease.

Then, manifest exophoria is a symptom, often of fatigue. The first step is to find if the fatigue arises from a latent hyperopia. If it does, make it manifest and correct it. Give the needed plus, don't worry about the exophoria.

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If it is not a case of latent hyperopia, find out what the trouble is. Do not treat the exophoria just because it is manifest. Find out why it is there. Remove the cause, do not attempt to remove or correct the exophoria.

Much is claimed by some manufacturers of exercising apparatus because by treatments, or exercises, with that apparatus, an exophoria is decreased. It is only a temporary betterment, if it may even be called a betterment. Tonicity has been built up for a few minutes, the exophoria is less for a few minutes. Do not give exercises just because you find an exophoria. You are as apt to do harm as do good.

In the cases of exophoria with latent hyperopia, what do we accomplish when we give base-out exercises to a patient?

We rebuild, temporarily, his ability to maintain his hyperopia latent. We have not reduced the amount of effort he uses in the convergence-accommodative function of covering the structural hyperopia. We only postpone for a short time his complete break down. A few weeks after we discontinue the exercises, he returns just as unhappy as he was at first. Instead of removing the cause, we have temporarily covered it up. When he comes back, we find the same amount of exophoria as before we gave the exercises, sometimes more. Of course we do. He is tired out again. Had we uncovered his latent hyperopia with base-in prisms, had we given him the needed plus lenses, we should have had an ever grateful patient instead of a discouraged one.

Let us remember what exophoria is—a sign of fatigue and low tonicity. Let us remember what exercises that reduce the manifest exophoria really do—they temporarily build up tonicity. Let us cease thinking of manifest exophoria as a cause of discomfort. Let us begin to think in proper terms, that manifest exophoria is a sign, and only that. Let us look for causes instead of meddling with the effects.

The ideal case seems to be one in which we find 1 Δ to 3 Δ of exophoria at distance. It would seem that these persons are those who are able to relax a bit when there is opportunity. The esophore cannot relax at all. Note the characteristics of the esophores, they are always on the go, they don't know how to sit down with folded hands. Note the characteristics of the high exophore, he is only too glad to sit down, nay, to slump down.

But there is one thing that we must watch about these low exophores. Given the opportunity to relax a little and they relax. Such opportunity is afforded in the phoria test. More important, it is also afforded when we occlude one eye.

Some people relax convergence-accommodation a little when one eye is covered. Others do not. If they do, then they accept more plus in the monocular test than is comfortable binocularly.

If we wish to work monocularly, then we must make a phoria test before refraction and again after refraction with the accepted monocular corrections in front of the eyes. If we find we have increased an exophoria we must either reduce the plus until we have the same amount of exophoria (or orthophoria, if that were the first finding) as we had in the beginning, or we must give base-in prism equal to the amount of exophoria we created by our monocular corrections. For instance, if a man shows 2 Δ of exophoria with his old glasses on, or without glasses if he has never worn glasses, and we find that with the plus lenses giving the best monocular corrections there is 6 Δ of exophoria, then we must give base-in prisms, 2 Δ to each eye to equal the 4 Δ of additional exophoria created.

The comfortable cases seems to be those showing 2 Δ or 3 △ more exophoria at near than at distance. To find more than this difference or less than this is not a good sign.

To find the same phoria at near as distance, for example, orthophoria at both near and distance, some exophoria at distance and exactly the same amount at near, or some esophoria at distance and the same amount at near, may be considered as a sign of latent hyperopia. That person is making more effort at close work than should be permitted. He is not yet tired out from doing it, but sooner or later he will begin to wear down and then we shall find a high exophoria at near.

Esophoria or orthophoria at distance with high exophoria at near, in persons who do much close work, or in persons going toward middle age, is a sign of latent exophoria. The difference between a man of 30 with 4 △ of esophoria at distance and 2 △ of esophoria at near and a man of 35 with 4 △ of esophoria at distance and 10 △ of exophoria at near is that the man of 30 is still unfatigued while the man of 35 is tired of carrying the load.

The difference between the distance and near phorias has been called physiological exophoria by some. While some allow as high as 6 △ of physiological exophoria, saying that any excess of this is some other kind of exophoria, though they fail to state just what fancy name is to be tacked to it.

It is unfortunate that the term "physiological exophoria" was ever coined. It is meaningless, it is not correct usage of the word "physiological," it leads to misunderstandings and unnecessary, generally fallacious, theorizing.

Latent Hyperopia

The fundamental weakness in most advised procedures of refractive examinations is that the amount of the latent hyperopia is not determined. The majority of esophorias and exophorias that we

find, also of many of the hyperphorias, is latent hyperopia and the effort made to see clearly in spite of the structural hyperopia. No examination is complete, no examination is worthy the name, that does not include a careful study of the latent hyperopia and the effort the patient is using to cover it. We must learn whether that effort is causing him distress or if he is still caring for it without undue cost.

The method of using base-in prisms for disclosing the latent hyperopia has proved very successful. It has been in use in my own office since 1922. It has been used and is being used by scores of optometrists and oculists both in this country and abroad. It is no longer to be regarded as a speculative venture but as an accomplished fact.

The details of this method have been published so often that it seems unnecessary to here give more than a mere summary. The reader who is not acquainted with the method is referred to The Optometric Weekly, March 1, and March 8, 1928. Also to "The Modern Treatment of Binocular Imbalances."

Briefly, we give the patient some printed matter to read. We put base-in prisms in front of his eyes until convergence-accommodation is inhibited. Then the print is blurred, he cannot read it. Give him some plus spheres and the print. Put on some more base-in prism and the print is again blurred. Give him the plus sphere that gives him clear vision. Repeat this until diplopia occurs and you will have the latent hyperopia measured by the amount of plus sphere you have added.

The quickest way of working is to first correct the manifest error. With these lenses in place, proceed as above with the base-in prisms.

A more accurate way of comparing the amount of prism used with the amount of plus sphere obtained by the prism is to use the cross cylinder method. The cross cylinders are placed in front of the eyes with the plus axis horizontal. The target is the familiar card with horizontal and vertical lines. When the horizontal lines are blacker, or clearer, than the vertical lines, add plus sphere until all the lines are equal. If the vertical lines are clearer than the horizontal lines, add minus sphere. This preliminary test is to be made monocularly. It is wiser to use cross cylinders that slightly blur the vision. The astigmatism must be corrected accurately.

Binocularly, when the horizontal lines are plainer, add plus sphere, equal amounts to each eye. If the vertical lines are plainer, add base-in prism, until both horizontal and vertical lines are equally blurred.

Add more base-in prism until the horizontal lines come out blacker. Add plus sphere to make them equally plain. Record the amount of prism and the amount of sphere used. Add more base-in

prism until the horizontal lines come out again then add plus sphere until all lines appear alike and record the amounts of prism and sphere added. Proceed in this way until diplopia occurs.

We have done considerable investigation in order to learn if at the point of diplopia we actually have all the latent hyperopia. We can leave the plus spheres thus found in place and educate the abduction up to 60 Δ or 70 Δ, but we do not thereby find more plus. Sometimes we get an extra 0.25 D., but no more.

There is a method of binocular monocular testing that is very excellent. By this we can measure each eye separately, yet both eyes are open and binocular functions are studied at the same time.

We may use either the cross cylinder method or we may use a short column of printed matter. The test chart is set at the reading distance. Base-down prism over the left eye and base-up over the right eye are supplied until the patient sees two targets, one above the other. The upper target is that seen by the left eye, the lower target belongs to the right eye. Using the cross cylinders, we equalize the appearance of the lines in each of these targets. Using print, we supply that plus that makes the print appear the plainest.

Supply base-in prism to correct the manifest exophoria. Now, in one or both of the cross cylinder targets, the horizontal lines will be the blacker. Add plus spheres to equalize the lines. Check from one eye to the other two or three times, for, frequently, addition of plus sphere to one eye will make the accommodation of the other relax. Or, if using the print instead of the cross cylinder, add all the plus sphere possible without blurring the print in the least.

The addition of this plus will create an exophoria. Add base-in prisms to correct this, to set one image above the other. At once, more plus is needed. At each addition of prism and sphere, record the amounts of each.

When the addition of more prism does not further relax the accommodation, or the addition of more sphere does not cause more exophoria, we have the measurement of the latent hyperopia for each eye.

This test is particularly valuable when the ophthalmometer shows equality of corneal base curves but skiascopy shows difference in the sphere for each eye. Or when the ophthalmometer shows a difference of base curves of the two corneas but skiascopy and subjective tests show equality of spherical corrections. This will be discussed later.

In myopia, we use this method to learn how much the myopia may be reduced. Whatever plus is added during this test with base-in prisms, that much can eventually be deducted from the minus spheres that correct the manifest myopia, by using the methods detailed in the discussion of myopia.

These have been subjective methods. The same method may be used objectively with the skiascope. First, correct the manifest error as usual. Then add base-in prism until the shadow movement is "with." Add plus sphere to neutralize. Add more base-in prism. The movement is "with." Add plus sphere. Continue this procedure until the addition of prism does not change the shadow movement. At this point the patient will see double.

We find that this method has been known for years, has been successfully used for at least thirty years. Dr. H. E. Allen, writing in 1898 says, "By this method you will find more latent hyperopia than with atropine." I have proved this by the comparative examinations of more than 400 cases by atropine and by the base-in prism method. In about 72% of these cases we find practically the same amounts of latent hyperopia by the two methods. In the balance we found from one to six dioptres more with the base-in prisms than with the atropine.

Do not think because the patient is well along in years that there is no latent hyperopia. We found one woman of 58 wearing + 2.00 spheres with + 2.50 correction, fitted and checked repeatedly by the reputed masters of dynamic skiametry, men to whom you have listened at state and national conventions, whose magazine articles and books you have read, all agreeing that this was the full error. Yet we found that her hyperopic error was 8 Δ. O. U., and that she needed to wear + 6.00. In the glasses she was wearing were incorporated 14 Δ of vertical prism for the correction of a manifest left hyperphoria. The larger part of this disappeared when she was given the needed plus. Her greatest difficulty had been the constant changing of the manifest hyperphoria and a continual shifting of the corneal astigmia, this constantly changing both in amount and in cylinder axis. The astigmatism settled down to O. U. + 2.00 D. Cyl. Ax. 90 as soon as the needed plus sphere was fitted.

I believe the first use of base-in prisms with dynamic skiametry was in England. At any rate, it has been in use by optometrists there for several years for determining the latent hyperopia.

Dynamic skiametry with spheres alone will not reveal the full latent hyperopia, despite the claims of many of its ardent advocates.

This question is often raised: Since this test is made at the reading distance, is not the plus so found in reality the amount of accommodation used at that point? In other words, if the test is made, say, at a distance at which uses 2.50 D. of accommodation, and we find, on repressing convergence-accommodation with base-in prisms, say, 3.50 D. of plus, is not 2.50 D. of this the accommodation the patient is using at that distance, with the true latent hyperopia 1.00 D.?

Instead of wasting time in theoretical discussion, let us set down the facts as we have found them.

1st. Examination under atropine, as we have said, in 72% of the cases gives as much plus as does the base-in prism method.

2nd. More important than the first point. Often we find only + 0.50 or + 1.00 or + 1.50. If the accommodation used to get clear vision at the distance of the test object is 2.50., then we ought to always find at least that 2.50 D. The majority of cases show less than this.

3rd. In every case, we can make the patient wear for clear distant vision, 20/XX, 20/XV or 20/X, whatever his previous vision was, the full plus correction found with base-in prisms at the reading distance.

We do not believe that it is advisable to go to that extreme, save in rare instances. Usually, we think it better to leave some of the hyperopia latent.

There are even some theorists that have said that base-in prisms would not reveal the latent hyperopia. When put to the point, these speculative writers admit they have not given the method a full investigation. Let them work out five or six hundred cases and then we shall feel disposed to listen to them. Until then, we give no heed to their theorizing.

The proportion of the latent hyperopia that is to be corrected seems to bear some relation to the negative relative convergence.

Negative Elative Convergence

By relative convergence is meant the amount of convergence that can be forced or relaxed without altering the focus of the image, that is, without affecting the accommodation.

It is said that the amount of positive relative convergence is measured by the amount of base-out prism that can be supplied without blurring the image. When the image is blurred, if the accommodation has been incited, the images will be in front of the tips of the cones. Minus lenses, by setting the images back to the tips of the cones, will make the images seem sharp.

Our common expression, "the image in front of the retina," or "behind the retina," is not exactly right. For the image may be slightly blurred and still focus within the layers of the retina. The image appears sharp when it is focussed at the tips of the cones.

However, in using base-out prisms, we find that there are a great many persons to whom the image seems blurred after 10 △ or 12 △, or some other amount, are supplied, but for whom minus lenses do not clear the images. So there is something here that we do not understand and which needs some investigation.

According to the definition of negative relative convergence, it is equal to the amount of base-in prism that can be supplied without the image becoming blurred.

When the image is blurred, if the accommodation has been relaxed, the images would be in focus behind the tips of the cones. Plus spheres, which bring the images forward, put them into focus at the tips of the cones, the images appear plain. The amount that the accommodation has been relaxed is indicated by the strength of the plus spheres that make the images sharp.

I have found, in my own experience, but one case in which, after the images blurred, they were not cleared by plus spheres. In all other cases, the images were made clear by plus spheres after they had been blurred by the relaxation enforced by base-in prisms. I have no exact record of the total number of persons thus tested. My own office records show over 1600. In addition to these, there have been several hundred tests at conventions and clinics. I should like an explanation of the one exception.

The amount of the negative relative convergence seems to be an index of the need of the patient for plus spheres. When the negative relative convergence is high, there is proportionately less need of plus. The lower the negative relative convergence, the more acute the need for plus lenses.

In the perfectly comfortable case, we find that the negative relative convergence equals the meter angle of convergence used for the distance at which the test card is set. For instance, if the test is made at 16 inches, that is 2.5 meter angles. If the interpupillary distance is 60 mm., or 6 cm., the prism diopre equivalent is $6 \times 2.5 = 15\ \Delta$. If the p.d. is 6.4 cm,, with 2.5 meter angles, the prism dioptre equivalent is $6.4 \times 2.5 = 16\ \Delta$. We find that when the negative relative convergence equals this amount, the patient is free from stress occasioned by latent hyperopia, even though we find 2.00 D. or 3.00 D. total. That is, if this amount of prism can be put on without the images becoming blurred, there is no immediate need for prescribing plus spheres, even though with more base-in prism we find quite a bit of latent hyperopia.

But when the negative relative convergence is very low, only 6 Δ or 10 Δ, and sometimes there is no negative relative convergence whatever, the use of plus spheres is imperative. The amount of negative relative convergence will vary according to the method we use for measuring it. The definition says, "when the image is blurred." But this is not sufficiently accurate. Few people have the same idea of blur that the refractionist has. The focus of the image may be quite a bit off the tips of the cones before they speak of the blur. This is particularly true of persons with small pupils. Then there is the question

of the focal depth of the eye, which focal depth varies quite a bit in different eyes. Under the cross-cylinder test, the instant that the horizontal lines come out black and clear, we have passed the limit of the negative relative convergence. This is more accurate than seeking to learn the point of blur. The negative relative convergence when measured by the cross-cylinder test is about half the amount found by using print and inquiring when the blur appears.

The amount of plus sphere that must be prescribed is that amount that will leave the negative relative convergence at the ideal point, the equivalent of the meter angle of convergence used at the reading distance.

The Plus Correction

Having determined the latent hyperopia, the next question to be answered is: How much is to be corrected? One way is to take the amount of plus found by the time the prisms have been increased to the ideal point of negative relative convergence. But we have found, in actual experience, that sometimes this has not proved sufficient, that more must be added later.

Now, if we will make a record of the amount of plus sphere found to given units of prism, that there is a point at which the proportion of plus to prism grows less. That is, if we record the amount of sphere to each 2 Δ of prism, (1 Δ over each eye) that in the beginning we get very small amount of sphere, say 0.25 D. of sphere to 2 △ of prism. Then, as convergence-accommodation begins to let go, we get perhaps 0.50 D. of sphere to 2 △ of prism. The proportions vary greatly in individuals, evidently in proportion to the degree of fatigue, the avidity with which the central nervous system grasps at the relief afforded. Then, after a time, once more the proportion of sphere to prism begins to decrease.

The amount of plus to be prescribed is gauged by the point at which the proportion of sphere to prism begins to decrease.

In actual office practice, we find that it is satisfactory to record the amount of plus sphere found to each 4 △ of base-in prism. And when the proportion of plus sphere to each 4 △ of prism begins to grow less, we prescribe for wear all the sphere found up to the point where the proportion of sphere to prism begins to grow less.

When this amount of sphere is prescribed, the negative relative convergence remains at the ideal point up to the time that presbyopia appears.

Having determined the amount we are to correct, the next thing to do is to cultivate in the patient the habit of convergence-accommodative relaxation, or, the same thing, to break up his habit of convergence-accommodation, so that he can wear the full plus correction without blur.

This is far more effectively done by wearing base-in prisms and giving base-in exercises than by putting on "fogging lenses." We know that there are a few people who will succumb, after a time, to the wearing of fogging lenses. We also know that this number is a very small minority. The average patient, moreover, will be so annoyed by the blur that he refuses to wear the glasses. We have outstanding examples, within our own ranks, of men who have advocated fogging lenses, have worn such lenses, themselves, for 15 to 20 years, but who, after all those years, have not relaxed sufficiently to see clearly at a distance through those lenses. They have been comfortable, because they have sufficient plus to enable them to do their close work without undue effort and they have resigned themselves to blurred distant vision, have denied themselves the pleasure of seeing clearly that which goes on about them. There are few of our patients who will thus resign themselves. The reason they are latent hyperopes is that they want to see clearly, must satisfy their curiosity as to the happenings in their environment.

But these latent hyperopes with low negative relative convergence at near must have the help of plus lenses at their near work. Nowadays, nearly every one gains a livelihood at close work, and we must take care of their near work requirements.

The answer is, give them, temporarily, bifocals so they can do their near work without strain and can see clearly at the distance. The sacred age of 40 has nothing to do with it. This is what they need, what they must have. Give them some base-in prism to wear, incorporated in the distant prescription. This will break up the convergence-accommodation habit, soon they will accept more plus for distance. Since the wearing of base-in prisms will increase their abduction, they will accept more for constant wear and this acceptance of more prism carries with it the acceptance of more plus.

Let us illustrate this by the recital of an actual case. Man of 35, doing desk work, suffering terrible headaches. Wearing, O. U. +0.25 Sph. () +0.75 Cyl. Ax. 90, prescribed under homatropine. Vision without glasses, 20/XX, with these lenses, 20/XX. Esophoria at distance, 4 Δ. Exophoria at near, 12 Δ. Static skiascopy: O. U., +0.25. Dynamic skiascopy: O. U. +1.25. Distance abduction: Break at 8 Δ, recover at 6 Δ. Near abduction without lenses: Break at 12 Δ, re-

cover at 10 △. Near abduction with O. U. +1.25: Break at 18 △, recover at 16 △. Negative relative convergence: Distance, 4 △; near, 0 △. Total latent hyperopia, +3.25 △, O. U. with 24 △ of base-in prism. The proportions of sphere to prism increased up 18 △ of prism with +2.75 sphere, then decreased.

With +2.75 D. Sph. O. U., in place, gave him a few minutes of base-in exercises at near. He then accepted the full +2.75 D. for reading without prisms. The recovery point in the distance abduction test is 6 △. So gave him one-third of this, 2 △, or 1 △ before each eye. Then reduced the plus to give him his normal vision at 6 meters, 20/X. He accepted O. U. +1.00 D. Sph. () 1 Δ base-in. Without the 1 △ prism, O. U., he accepted +0.50 for 20/X vision.

Then the first prescription was O. U., +1.00 D. Sph. () 1 Δ base-in, add O. U., +1.75 D. The cylinders on the lenses he was wearing were not needed. Gave him a half-hour of base-in exercises daily. In three days, he accepted for distance, O. U., +1.50 D. Sph. () 2.00 Δ base-in, vision, 20/X. Add +1.25 D. for reading.

After another week of wearing these, together with the base-in prisms, he accepted for distance, with 20/X vision, O. U. +2.00 D. Sph. () 2.50 Δ base-in, add +0.75 for reading. In another week he accepted, with 20/X vision, O. U. +2.75 D. Sph. () 3 Δ base-in. After a month, the prisms were removed, he had 20/X vision with O. U. +2.75 D. Sph. 18 months later he was re-examined. Negative relative convergence: Distance, 6 △; near 20 △. Latent hyperopia, O. U., +0.50 D. Sph.

This illustrates the quick way of getting on full plus correction. If the patient cannot come in for daily exercises, prescribe the bifocals and prisms, change them every three months or so.

Prism Prescription

The eye is rotated to put the fovea beneath the image of the object in which we are interested. That is the only purpose of eye rotation. When the fovea reaches the image, the rotation ceases.

Fusion is the result of the two foveas standing beneath the two images. We have probably given too much credit to the fusional impulse as a factor in ocular rotations. The fovea seeks the image. If both foveas succeed in reaching their respective images, we see singly.

When the image is to the nasal side of the fovea, the command delivered from the cortex is an order to shorten the external rectus and lengthen its antagonists. The fovea turns nasalward, to the image. The visual axis swings temporalward. We say, "The eye turns outward," because we see the motion of the iris and pupil away from the nose.

When the image is at the temporal side of the fovea, the command is to shorten the inturning muscles and lengthen their antagonists. The fovea turns temporalward to the image, the visual axis turns nasalward. We say, "The eye turns in," as we see the pupil and iris turn toward the nose.

When the two images are on the temporal sides of the two foveas, the inturning muscles of both eyes are shortened, their antagonists lengthened. This is what we call convergence. Convergence is a direct reflex arc, a muscular response incited by the appearance of the images at the temporal sides of the two foveas. Or, if one fovea is already beneath its image while the other image is at the temporal side of the fovea of that eye, then that one eye converges. There is nothing psychic about the act of convergence. Most of the writings about the function of convergence should specify convergence-accommodation instead of using the simple word, convergence.

When the two images are at the nasal sides of the two foveas, the order is to shorten the outturning muscles and lengthen their antagonists. The two foveas are swung nasalward, the visual axis swing outward. This is what is misnamed "negative convergence."

Wherever the image falls, when it is off the fovea, the muscles are incited, by that sensory stimulus, to so act, some shortening, some lengthening, that the fovea shall move to the image.

This is the principle that must underlie our prism prescriptions.

When an eye's attention is fixed on an object, the image of that object is on that eye's fovea. When we put a prism in front of that eye, the image is deflected off the fovea. The fovea is at once turned to the new position, beneath the base of the prism. The visual axis, therefore, moves toward the apex of the prism. We see the pupil turn toward the apex of the prism. The muscle beneath the prism base is lengthened, the muscle beneath the prism apex is shortened. Tonicity is sent to the muscle beneath the prism apex. A proportionate amount of tonicity is withdrawn from the muscle beneath the prism base, for the innervation of that muscle has been inhibited.

The esophore does not "over-converge," when he is looking at an object with both eyes. Both foveas turn to their images and halt there. It is only during the phoria test or when one eye is occluded that one of them turns in. Both do not turn in during the phoria test. We have made observations that the eyes take turns in fixing their objects. When we use the maddox rod test, one eye looks at the light, while the mind is occupied with the light, while the eye over which the rod is placed turns inward. Then we ask the patient if he sees the streak, that eye turns to the image of the streak, while the other eye turns in. When we ask him to think about light and

streak, the eyes shift rapidly, alternately fixing light and streak. When we remove the rod, both assume the position in which the two foveas are, beneath the two images of the light.

The orthophore does not turn either eye when we put the rod in front of one eye. The tonicity of all his muscles is equal, so he holds both foveas beneath their images.

When we put the rod over one eye of an exophore, he lets one eye turn outward, then fixes streak and light alternately, turning the eyes alternately to put the fovea beneath the image of the object he is thinking about, alternating as he alternately thinks definitely about the light or the streak. We cannot think with equal intensity of two things at the same time. We alternate the intensity of our attention between the light and streak. The foveas turn alternately in response to our alternating attention.

Esophore, exophore, orthophore are all alike when both eyes are looking at the same object. The two foveas are beneath the two images, the visual axes intersect in the object.

So when we put prisms, either base-in or base-out, before any binocularly functioning pair of eyes, in deflecting the images off the fovea, we compel the innervation of the muscles beneath the prism apices, compel the inhibition of the muscles beneath the prism bases. There is no such thing as "prisms in position of rest." Prisms compel muscular innervations and inhibitions, no matter what their position before the eyes.

When we put base-out prisms before an esophore's eyes, the images are deflected to the temporal sides of the two foveas. Therefore, in response to that sensation, the converging muscles are shortened, their antagonists lengthened. To maintain the shortening of the converging muscles, tonicity impulses must follow and tonicity impulses must be withdrawn from the external recti.

But the converging muscles of the esophore are already in a state of hyper-tonicity, the external recti in state of hypo-tonicity. With our base-out prisms we are simply increasing a bad fault. So, after a time, the patient comes back with more esophoria and his headaches have returned. We give him more base-out prisms, make him still worse.

Supposing we should give him base-in prisms. Then the images are deflected to the nasal sides of the foveas. The outturning muscles are innervated, shortened. The inturning muscles are inhibited, lengthened. Tonicity is withdrawn from the converging muscles, which were in a state of hyper-tonicity. Tonicity is sent to the outturning muscles, which were in a state of hypo-tonicity. Let him

wear those prisms for a time. The esophoria disappears. Why? Because all the muscles have been developed to a state of equal tonicity.

When a muscle is in a state of hyper-tonicity, the only way to reduce that tonicity is by its continual inhibition. That is the reason that exercises for a few miutes daily fail to eliminate esophoria.

I doubt the advisability of giving base-out prisms to wear in cases of exophoria, merely because there is an exophoria. Though such prism wearing will eliminate the exophoria. But the cause has not been eradicated. We must seek out and remove the causes of exophoria, not treat the exophoria.

Base-in prism wearing for an exophore, when they are giving in the so-called correction of the exophoria, increase the exophoria because they inhibit the tonicity of the convergence muscles, which are already in a condition of hypo-tonicity.

Base-in prisms are given to the latent hyperope, whether he is an esophore, an orthophore or an exophore. Not because of his manifest phoria but to hold the convergence-accommodation in check that we may get on the needed plus spheres. When the spheres are accepted with clear vision without the prisms, then we may remove the prisms. But the prisms cannot be taken away so long as the esophoria is present.

Base-in prisms relax hyper-tonicities not associated with latent hyperphoria. Base-in prisms, by breaking down hyper-tonicities, by equalizing tonicities of all muscles, increase ductions in all directions. The quickest way to create a high induction is by base-in prism wearing.

Base-out prisms force into activity the function of convergence-accommodation. They are, therefore, valuable in the development of this function in cases of immature, or arrested development of the convergence-accommodation function.

Base-out prisms can make the manifest hyperope into a latent hyperope. They force him to attention to sharp vision. He who doubts this has only to use his skiascope, neutralizing a "with motion" with base-out prisms instead of with plus spheres. It is not a very wise thing to do, but it can be done.

The prescription of base-in prisms is not based on the manifest phoria but on the abduction. The latent hyperope can wear one-third of the recovery point in the distance abduction test without being conscious of distortion.

The distortion experienced by the latent hyperope is due to the inhibition of the superior obliques, which are, it is now thought, the chief extrinsic muscles used in the act of convergence-accommodation. The physiologists are destroying our carefully nourished traditions about the 3rd nerve and the internal recti and their activities in association with accommodation.

The superior obliques not only rotate the eyeballs but tort the upper ends of the vertical meridians inward. When we inhibit its innervation, by base-in prisms, evidently the vertical meridians are torted, if not completely outward, at least less inward. Thus we get the distortions complained of.

Just why the latent hyperope does not notice the distortion when he has on no more than one-third of the recovery point in the distance abduction test, I do not know. The figure has been arrived at through experiment with a good many hundred individuals. And, after all, this is a better way to arrive at methods than by mere hypothetical reasoning, since, too often, the factors on which we base our hypotheses are not facts but are themselves unsound theories.

Esophoria Without Latent Hyperopia

Among young women, from 18 to 30 years of age, we often find esophoria that is not due to the efforts of compensating a structural hyperopia. The symptoms are headaches, very acute and persistent. The pupils are large. Dynamic skiascopy sometimes gives an "against motion," though they do not need minus lenses. In the majority of cases, dynamic skiametry shows +0.50 D. or +0.75 D. Sph, but prescription of these plus spheres aggravates the headache. Ductions are low.

These cases are psychopathic. Do not prescribe plus spheres. Give base-in prism for constant wear. The amount wearable is one-half the recovery point in the distance abduction test. For example, if distance adbuction is, say, break at 6 Δ, recover at 4 Δ, we can give O. U. 1 Δ base-in.

If the near abduction is low, only 12 Δ or 16 Δ, give, for temporary wear, about 2 Δ additional for near work. Give cemented bifocals, plano prism segments.

If the distance abduction is so poor that no prisms can be at first prescribed for constant wear, give plano uppers with 2 Δ base-in, O. U., as cemented segments.

The use of the base-in prisms for near will soon develop the distant abduction so that more prism can be worn for distance. Work up to about 3 Δ base-in, O. U. These are worn for a few months, until the esophoria has disappeared, They are then discarded, The headaches discontinue immediately, or within a couple of hours, when the first prisms are put on.

An eminent neurologist prescribes, "Base-in prisms and join a dancing class." Which is good advice. Contact with people, active exercise, cold baths, assist in breaking up the psychosis.

Sometimes a young man or woman recovering from the mumps will show an esophoria. With this there is often a left hyperphoria of right handed persons, or a right hyperphoria with left handed persons. Give base-in prisms, one-half the recovery in the distance abduction test. Disregard the hyperphoria.

There is a rare esophoria with right hyperphoria in right handed persons, or esophoria with left hyperphoria in left handed persons. This is not so very common. The solution is the prescription of vertical prisms in the position and the amount that corrects the manifest hyperphoria. This eliminates the esophoria. The hyperphoria in this type does not increase by wearing the correcting vertical prisms. Most hyperphorias increase when prisms are given to apparently correct the manifest error.

Myopia

We know nothing of the causes of myopia. There have been many theories advanced in the past, such as heredity, a stooping position while lifting weights, stooping position while reading, bringing the reading too near the eyes, as myopic children do, thus inciting over effort of convergence and over effort of accommodation, bringing on the so-called "spasm of accommodation;" reading and studying "too much;" structural error of low hyperopia and high exophoria, so that convergence, in seeking the single image, "carries accommodation too far," and so on without end.

None of these theories is anything but speculative. There is not one bit of scientific research behind them. They are but typical of the guessing contest that has been so prevalent in our literature. So far as "Spasm of the Accommodation" goes, there can be no such thing.

In dissecting myopic eyes, we find that the meridional fibers of the ciliary muscles are over developed, in a state of hyper-tonicity But this is not "Spasm of the Accommodation." It is a tetanus, or myo-spasm, of a single bundle of the three bundles that make up the ciliary muscle. We also find, in studying the ciliary muscle of the myopic eye that the circular fibers are atrophied, likewise the radial fibers are under developed. But the circular fibers are used in the act of accommodation, in the act of willed, or forced accommodation in association with convergence. In the hyperopic eye that has habitually compensated a part or all of its structural error by forcing the convergence-accommodation function, we find that the circular fibers are strongly developed, in fact, hyper-trophied, indicating a constant state of high tonicity. And the radial fibers are few and hard to find, while the meridional fibers seem about normal. And this is the so-called "Spasm of Accommodation" of the latent hyperope, a hypertonicity, because of continual use, of one section of the ciliary muscle.

To say "Spasm of the Accommodation," is to infer the spasm of a function. But functions do not have "spasms." One of the individual muscles used may be in a state of undue contraction, which is known as a tetanus, or myo-spasm. But that is not a spasm of the function.

All we know about myopia is that it is. It is not congenital in healthy children. Such children are born hyperopic. The few records we have of babies but a few days old, that are myopic, are records of diseased babies.

We have this much information. That adults with certain digestive disorders sometimes become myopic, or, if they have been slightly myopic for years, they become more myopic as the digestive disturbance increases. Some children we have examined when myopia first appeared have been prematurely adolescent. We do not know whether this is a co-incidence or whether premature adolescence is a factor in causing myopia. In this connection, we have the statement of statistic medicine that the age of adolescence is advancing, that the children of the present day are maturing at an earlier age than did those of preceding generations. We also note that myopia among children is on the rapid increase. What connection there is, where there is a connection, between these two sets of statistics, we do not know. It may be only a co-incidence, it may be of supreme importance.

The present view is that myopia is caused by a disturbance of metabolism. They say that the myopic eye is deficient in blood supply. But these are only surface indicators. We shall have to know more than we now know about metabolism and blood circulation before those theories can be proved. Probably, when we solve the riddle of the endocrine glands, that solution will also carry the solution of the origin of myopia.

At any rate, though we do not know the cause of myopia, we have found a means of controlling it to a certain extent. And that method I am now to describe. Do not imagine that I think this is a finished method. As we know more we shall be able to improve it. I can only give you what we have done to date.

The following is a brief summary of a successful procedure with all myopic cases, whether it be with manifest exophoria, orthophoria or esophoria.

First. Determine the amount of the manifest myopia by the usual objective and subjective methods. Find the lenses that give best vision, using plus cylinders in the correction of any astigmatism.

Second. Take the distance abduction, finding the amount of base-in prisms that cause diplopia. Use a large letter or a picture rather than a spot light. The abduction will be higher. A picture about six or eight inches square is best if vision is good.

If abduction is high, 10 Δ to 16 Δ, perhaps more, you will find that the minus lenses can be considerably reduced by giving base-in prisms to wear. Or, when the vision is low, when the abduction is high, vision is greatly improved by base-in prism wearing, even when the reduction of minus is not much. When the distance abduction is low, only 4 Δ or 5 Δ, not much minus will be taken off.

Third. Reduce the prism to the point of recovery, that is, to the point where single vision is regained.

This is an important point, for this amount of prism at which the patient recovers single vision is the amount of base-in prism to be prescribed for constant wear.

For example, supposing the break is at 10 Δ, recovery at 6 Δ. Prescribe this 6 Δ, divided equally between the two eyes, 3 Δ to each eye, bases-in. Suppose the break is at 14 Δ with recovery at 10 Δ. Give 5 Δ over each eye. If the break is 4 Δ with recovery at 2 Δ, you can give but 1 Δ over each eye.

Fourth. Remove all the minus spheres. There is now nothing in the trial frame, or in the refractor or phoropter or kratometer, whatever you are using, but base-in prism, and in cases of astigmatism, plus cylinders.

Fifth. Build up the minus correction in quarter dioptre steps to the point of best vision. Both eyes are uncovered. All work is binocular.

In myopia of —0.25 to —1.00, without astigmatism, when vision is 20/XX with the minus correction, vision with the base-in prisms is sometimes 20/XX. Then, of course, no minus is to be prescribed. These prisms are worn for a few weeks, until monocular vision without lenses is 20/XX. Then the prisms may be discarded. To give half an hour of base-in exercises four or five times a week will hasten matters.

These cases should be kept under observation for a time. If boys can be got safely past the age of 18, it seems to be safe to leave them without further attention. But girls should be kept under observation, checking up every two or three months, until fully matured.

Vision is almost always better with base-in prisms without minus spheres than with naked vision, even in cases of very high myopia.

If the manifest myopia is 8.00 D. or more, the first steps of building up the minus correction can be made in —0.50 D. steps.

If the myopia is very high, say 14 D. or more, the first few steps can be with -1.00 D. spheres. But in low and medium myopia, build in -0.25 steps.

Be in no haste in adding successive powers of minus spheres. At each step, pause a bit, inquire how much, what letters, of the test chart can be seen. When vision is less than 20/CC, when nothing can be seen of the test chart at 20 feet, put an ordinary card test chart near enough to the patient so that the 200 foot letters can be seen. And as minus lenses are added, step by step, the chart may be set back, until some of the letters in the regular cabinet at 20 feet can be seen.

Where one eye is more myopic than the other, the difference, as found in the skiascopic test, or in the first subjective test, may be given to that eye before the binocular correction is built up. Or, preferably, build up the binocular correction with equal lenses until vision with the better eye is at its highest, then add what the poorer eye may need. Often, working this way, we may avoid as much difference in the correcting lenses as at first seemed needed. In these cases, sometimes we get very good results by giving to the more myopic eye 1 Δ or 2 Δ more base-in prism than to the other eye.

When vision is 20/XX with minus lenses, it generally takes less minus with base-in prisms to give 20/XX, by following this procedure. To this there is one exception.

Myopia at the beginning is always "progressive." Some children progress but a little way, then stop entirely, never become worse. Some progress for awhile, then stop, enter what we might, though not scientifically, call a "resting period." Then the myopia commences to increase again. If we happen to make our examination during one of these progressive stages, then the same amount of minus is required with base-in prisms to give 20/XX vision as was needed without. However, follow this same procedure through and you will find that you can halt the progress of the myopia.

When vision is less than 20/XX with minus lenses, generally the same amount of minus used with base-in prism, when this building up procedure is used, will give 20/XX. Sometimes, even in these cases, less minus is needed to give 20/XX.

Even when 20/XX cannot be reached, there is generally a marked improvement in vision with the same amount of minus.

Sometimes, no improvement in vision is obtained at the first sitting. In those cases, the same vision as was formerly had with minus lenses will be gained with less minus when used with base-in prism. And after wearing those prism-spheres for a few weeks, there will be a very wonderful improvement in vision.

Sixth. If you have reached 20/XX vision by this procedure, reduce the minus sphere. In school children, college students, young persons doing much close work, as stenographers and bookkeepers, I usually reduce vision to 20/XL. Adults can be reduced to 20/XXX, it is not advisable, as a rule, to cut their vision down too much. I do this because, in a few weeks, vision will be 20/XX with this reduced correction.

In the case of school children, it is wise to phone to the teacher that you have given the child new glasses, that you have purposely given glasses that do not give normal vision, but that the child's vision will improve rapidly and will soon be normal, "as soon as she gets used to the glasses." This will avoid conflicts with the school nurse who has been told to insist that the children have 20/XX vision.

The lenses you now have before the patient's eyes make up the prescription you will order. Excepting in cases of astigmatism, when the plus cylinders are to be reduced by about a half dioptre. For we find that in myopic cases the corneal astigmatism can be reduced by base-in exercises and base-in prism wearing. It is thought that the same hyper-tonicity of the meridional fibers of the ciliary muscles that causes the myopia produces, because of the great tension on the tunics of the eyeball, the distortions of the cornea causing astigmia of its surfaces. Whether this idea is correct or incorrect, it is sure that the relaxing effect of the base-in prisms causes reduction of this tension and reduces the curve of the cornea, also reduces the corneal astigmia.

So when there is a cylinder in your correction, if that cylinder is 0.50 or less, ignore the astigmatism. Prescribe prism-spheres, without the cylinders. They will not be needed. In two or three weeks the corneal error will disappear and if the cylinders are given they will cause discomfort. In higher corneal astigmia, give about half dioptre less cylinder than found in the subjective or skiascopic test.

Seventh: Check the near correction, first by the skiascope, then subjectively. Using strong base-in prisms and reducing vision to 20/XL, we now give fewer bifocals to myopic children than formerly. But there are a few cases where bifocals are needed on the first correction.

In this test, the subjective test is more reliable than the skiascopic. For, oddly enough, we often find the seeming paradox of a myopic child in whom the convergence-accommodation is not matured. Then the skiascope shows a "motion with" at the reading distance, but plus addition is not needed, in fact reading vision is better without it.

Where an addition for reading is accepted, it will be found that on the second correction, made a month or two later, that what was the first reading correction becomes the new distance correction.

Eighth: Take the near abduction with the distance correction in place. In measuring this, you must include in your figures the amount of base-in prism that is a part of the distance correction.

For example, supposing you have 3 △ base-in on each eye, total 6 △ base-in. Then, in the near abduction test, 16 △ more is added before diplopia occurs. Then the break is 16 △ + 6 △ = 22 △.

After finding the breaking point, reduce to the recovery point. This recovery point, in any of the duction tests, is important as it indicates, to some extent, the degree of tension, or possible hyper-tonicity. This is not the "fatigue point," as has been falsely taught. A quick recovery, with reduction of but 2 △ or 4 △ from the prism that caused diplopia, indicates freedom from tension. A poor recovery, where the prisms must be reduced 8 △ or 10 △ or more, indicates a condition of stress, or tension. This tension may be caused by mental stress, as anxiety, or it may be caused by disturbances in either the digestive or sexual orgasms.

If in myopia, the breaking point is low or the recovery point is poor in the abduction test at near, it is wise to give some base-in prism segments. These are cemented to the distance lenses. Usually, they need be worn but a week or two. This is the quickest way, we find, to increase any of the ductions, induction, vertical duction, abduction. All increase under the relaxation of base-in prisms worn for reading. I find that to give 2 △ base-in segments is a very satisfactory amount, produces the results wanted.

If it has been found that plus addition is needed for reading, and the near abduction test shows that some base-in prism is needed in the segments, then these segments will be sphero-prisms.

An easy way to prove whether plus auditions will be helpful or not is to put a pair of + 1.00 D. spheres over the distance correction, then take the near abduction again with these + 1.00 spheres in place. If the near abduction is higher, that is, if more prism can be overcome without diplopia, or if the recovery is better, with these plus spheres than it was without them, then the addition of some plus sphere will be comfortable for reading. If such addition will be uncomfortable, or useless, then the near abduction will be less with the + 1.00 D. addition.

Ninth: When the patient comes for the finished glasses, before adjusting them or trying them on, give five or ten minutes exercises with base-in prisms, at both near and distance. Then the new lenses, with their strong base-in prisms, will be accepted without disturbing single vision and without disturbance to perspective.

The myope can wear more base-in prism than can the latent hyperope. Near vision to the myope is far more comfortable with strong base-in prisms than without. The general health is often improved following the wearing of strong base-in prisms.

Tenth: Give base-in exercises, daily if possible. If not daily, as often as the patient can come. This hastens the day when the lenses can be changed.

If no exercises can be given, as when the patient lives at a considerable distance, give an appointment for a day about a month later. Generally you will find that vision is up to 20/XX with the lenses that first gave 20/XL. If not, let the patient wear the same glasses for a few weeks longer.

If vision is up to 20/XX, or even to 20/XXV, go through the same procedure as before. Take the distance abduction, which will now be higher. Reduce the prisms to the recovery point, which will be higher. Use this amount of prism as the foundation for the new prescription. Remove the minus spheres, build up again in —0.25 steps to 20/XX, reduce to 20/XL as before. In cases of corneal astigmia, reduce the cylinder again.

This procedure is followed so long as any of the minus can be taken off. Sometimes you can take off 1.00 D. or 2.00 D. at a time. In other cases, you only take off —0.50 D. Do what you can. You can always increase the prism.

Do not be alarmed when you find 10 △ or 12 △ or more accepted. Give it to the patient. He needs it. You may temporarily increase the exophoria, but not probably. Usually the exophoria decreases. Remember what exophoria is, it is a sign of low tonicity. Forget that false teaching that exophoria is "convergence insufficiency."

If quite high prisms are prescribed, so that their weight becomes a burden, they may be reduced later, when as much of the myopia has been eliminated as possible. But leave all myopes with at least 2 △ to 4 △ base-in prism over each eye.

It is generally advisable to give bifocals, with plus additions and extra prism, to amblyopic eyes. Experience shows that if one eye is quite amblyopic, or if one eye is considerably more myopic than the other, that we get results much quicker by giving extra prism to that eye. Sometimes we have succeeded in bringing the two eyes nearer to equality by giving more prism in the distance correction to the eye that is more myopic. This does not always work, but it does succeed often enough to make it worth trying in every case.

So far, we have had no cases of myopia that have increased after this treatment was inaugurated. We have been using this method for seven years. At first, it was only tried on a few patients, then as it proved successful, and as we developed the technic, we used it with more and more cases. During the past four years, a great many men through the country, both oculists and optometrists, have taken it up, reporting considerable success. No one yet has turned in a report of a myopia that continued to increase.

Of course, I would not say that we have discovered a preventive to progressive myopia. Much more work needs to be done. As more men take up these methods they are continually inventing better ways, shorter cuts. As to the hindrance to progressive myopia, we might fairly say that these cases happened to be ready to stop progressing. On the other hand, out of several thousand, it does seem as though there might be a few that were not at that stage and that we would receive some reports of failure if the base-in prism method were not a strong factor in staying the advance of progressive myopia.

Drs. Ryer and Hotaling advocate giving enough prism on the reading correction to equal the meter-angle of convergence. I have not had an opportunity to study their case reports thoroughly. But they are conservative, careful workers, and do not announce results prematurely. Therefore, I would say, even viewing the matter from a logical standpoint, that this would be well worth doing. My own success in giving extra prism for reading supports their proposal. For whenever I have, by adding prismatic segments, brought the total reading prism up to 16 △ to 20 △, results have been very gratifying.

In myopic adults with esophoria, we generally find digestive troubles, usually hyper-acidity of the stomach. We find that when we refer such cases to alimentary specialists, who put the patient on a rigid alkaline diet, that the myopia and the esophoria are both reduced. We also find, that these specialists get along faster in curing the patient, with the aid of our base-in prisms. These seem to be two-man jobs, for neither one of us get along very well alone, but our combined efforts produce very satisfactory results.

All the cases I have seen, or had reported, of myopic children with esophoria have been cases in which minus lenses had been worn for some time and these minus lenses were over corrections. There has been no difficulty in getting rid of the esophoria with base-in prism wearing and exercises. I do not know if it is safe to assume that the esophoria is the result of the over correciton. But as we know that exophoria can be reduced by giving strong minus lenses, evidently forcing the convergence-accommodation act, it does seem likely that the over corrections were a factor, at least, in producing the esophoria in these children.

We can understand, at least we think we can, why base-in prisms should reduce some of the myopia. For these would inhibit convergence-accommodation, if there is an excessive effort, and by such inhibition would reduce the myopia somewhat. Personally, I am rather skeptical of this theory. There is much that we do not know and there is so much that is farcical in the theories about the associations of convergence and accommodation that have been presented in the past, that I would not care to accede to this speculation.

We cannot understand why base-in prisms should give such a remarkable improvement in vision. One eminent ophthalmologist says, "Tensions are removed, blood circulation is improved, of course vision is better." But this does not seem sufficient reason. We want to know how and why the tensions are removed, how and why the blood circulation is improved.

We find that in some cases, not in so very many, unfortunately, after we get up to considerable prism power, that the pupils, which are so highly dilated in myopia, grow smaller and the iris renews its functioning. It has always been said, in our text-books, that the myope has no, or very little, accommodation. But we always find some myopes with normally behaving accommodation. Now, we find, that after prism wearing, not only do the pupils grow smaller but the amplitude of accommodation increases. Evidently, by inhibiting the spinal sympathetic innervation of the meridional fibers, we make possible the para-sympathetic innervation of the circular fibers. The function of convergence-accommodation becomes operative. But we know too little, definitely, about the innervation of the different parts of the ciliary muscles.

We are hoping that the researches that are being financed by the American Academy of Optometry, researches into the innervational supply and the functions of the different sections of the ciliary muscle, will bring us the needed information and illumination of this matter which is so important but about which we are in complete ignorance.

Illustrative Cases of Myopia

Woman of 56. Wearing O. U. —16. D. Sph. Vision with these 20/LX. With O. U. 5 △ base-in () —11. D. Sph., vision 20/XXX.

Boy of 14. Vision 20/XXX. —1.00 D. Sph. O. U., vision 20/XX. With 1 △ base-in, O. U., vision 20/XX. Wore these four months, monocular vision, 20/XX. Glasses discarded. No recurrence of myopia in two years. Is now 16, with normal vision and complete comfort.

Girl of 19. Vision: O. D., 20/XXX; O. S., 20/XL. Wearing: O. D., —0.75 D. Sph. = 20/XX; O. S., —0.75 D. Sph. () —0.75 D. Cyl. = 20/XX. Very uncomfortable, especially at close work. Ophthalmometer: O. D. 0.37 D. Cyl. with the rule, plus axis 90; O. S., 1.50 D. Cyl. with the rule, plus axis 90. The lenses worn corrected the manifest error exactly. Distance abduction: Break, 4 △; recovery, 2 △. Near abduction: Break, 10 △; recovery, 6 △. Rx: O. U., 1 △ base-in; add, O. U., 2 △ base-in. Worn for one week. Distance abduction and near abduction both improved. New Rx: O. U. 2 △ base-in; add O. U., 2 △ base-in. Worn one week. Distance abduction: Break 10 △; recovery 6 △. Near abduction: Break, 22 △; recovery, 18 △. New Rx: O. U. 3 △ base-in; no addition. Worn one week. Vision: O. D. 20/XX; O. S. 20/XX.

Ophthalmometer: O. D. 0.37 D. Cyl. with the rule; O. S., 0.37 D. Cyl. with the rule. Note that the corneal astigmia had disappeared New Rx: O. U., 4 △ base-in. Worn for six months and discarded.

Woman of 30. Wearing: O. U. —1.00 D. Sph., vision, 20/LXXX. Naked vision, O. U., 20/CL. No lenses would improve vision above 20/LXXX. Was becoming alarmed over fact that vision had been growing steadily poorer for four or five years and no one had been able to give glasses to improve it. Fundus and media clear. Distance abduction: Break, 10 △; recovery, 6 △. Near abduction: Break, 24 △; recovery, 20 △. With O. U. 3 △ base-in, vision 20/LXXX. With 3 △ base-in () —1.00 D. Sph., O. U., vision 20/XL clear and a part of 20/XXX. Three months later, vision with this correction, 20/XX.

Woman of 46. Wearing: O. D., —3.50 D. Sph. () + 4.00 D. Cyl. Ax. 90; O. S., —3.50 D. Sph. () + 5.00 D. Cyl. Ax. 90, Vision with these, O. U. 20/XL. Loaned pair 4 △ prisms, bases-in, for a few days. Second examination: O. D., 3 △ base-in () —2.50 D. Sph. () + 3.50 D. Cyl. Ax. 90; O. S., 3 △ base-in () —2.50 D. Sph. () + 4.00 D. Cyl. Ax. 90; vision 20/XL. Worn for one month. Third examination: O. D,, 3 △ base-in () —1.50 D. Sph. () + 3.00 D. Cyl. Ax. 90; O. S., 3 △ base-in () —2.00 D Sph. () + 3.50 D. Cyl. Ax. 90; vision 20/XL. Worn for three weeks and vision had improved to 20/XL. Case reported by Dr. G. A. Crow, Los Angeles, Cal.

Woman of 33. Vision: O .D. 20/LX.; O. S. 20/LXX. Manifest myopia by static skiascopy: O. D. —3.00 D. Sph. () + 1.25 D. Cyl. Ax. 80; O. S. —3.50 D. Sph. () + 1.25 D. Cyl. Ax. 125. Vitreous hazy. Vision brought up to 20/XL O. U. with lenses. Did not prescribe lenses but had patient put on strictly alkaline diet. Suspected diabetes, but all tests negative. After two months of this diet, vision 20/XX. Media clear. No myopia. Corneal astigmia by ophthalmometer, 0.50 D. Cyl. with the rule, axes 90. This case proves nothing but does illustrate the factors that may produce myopia and corneal astigmia.

Arrested Development of the Convergence-Accommodation Function

Some people do not develop, to any great extent, the function of convergence-accommodation. Some accident, some upset in the vital organs, perhaps, interferes with the progress of the development of this function, just as other functions are arrested, or delayed, in their development.

We do not know just when the convergence-accommodation function begins to develop. Probably, when the child begins to take real interest in his surroundings. Perhaps before he is two years old, perhaps a little later. Doubtless there is the same variation in children as there is in the development of speech, in the growth of teeth, and so on.

It seems that it should be in a pretty good stage of development when the child is 11 or 12, but probably does not reach its full maturity, on the average, until he is nearly 20. In the years between about 8 and 20 we find the greatest manifest variations.

One thing is noticeable. All individuals with this handicap that we have found so far are descendants of out of door workers, of farmers, laborers, sailors, hunters, etc. We find none of these cases with an ancestry of bookish people or as descendants of families of skilled artisans. Perhaps heredity of functions is a factor in this peculiarity.

The symptoms are: Poor vision at distance with no complaint about it; the complaint is of distress at close work, both among adults and school children; the pupils are larger than we should expect to see them at the age of the patient; (pupillary contraction is an associate of the function of convergence-accommodation, not of accommodation as was taught in our earlier text-books); more plus is shown both by static and dynamic skiascopy than the patient will accept for clear vision; there is an unusual difference between static and dynamic skiascopy, what has sometimes been called, we think erroneously, "lag of the accommodation"; this difference between static and dynamic is from 1.00 D. to 4.00 D., when we expect, from the age of the patients, a difference of half that amount; the plus shown in static skiascopy will not give 20/XX vision; no plus correction that we can try will bring vision up to 20/XX; the fundus is healthy and the media clear in both eyes.

In comparing static and dynamic skiametry, the observer and his mirror should be at the same distance in both tests and the same working distance is to be deducted in both tests. The habit of making the static test with the observer at one distance, and the dynamic test with the observer at a nearer distance, makes impossible a usable comparison of the two.

In very young children, the difference between static and dynamic skiascopic findings is quite high, usually around 3.00 D. As they grow older, as the function of convergence-accommodation develops, the difference grows less. If it does not develop, the difference remains high as in early childhood.

In very small children, the pupils are very large. As they grow older, as the function of convergence-accommodation develops, the pupils grow smaller. If its development is arrested, the pupils remain large, as in childhood.

Recital of some cases will illustrate, give a better conception than further discussion.

Girl of 11. Complaint, eyes hurt when studying. Nationality, Jugo-Slav. Vision, 20/XL. Static skiascopy, O. U., + 2.00 D. Sph. Vision with these, 20/XL. No change of sphere, greater or less, would improve vision. Dynamic skiascopy, + 4.50 D. Sph. Could not read as well with these as without. Base-out prism, 2 △, O. U., neutralized with move-

ment. These gave 20/XX vision. They were worn for six months. Then, monocular vision was 20/XX for each eye. Reported complete comfort. Four years later, was perfectly comfortable.

Boy of 7. Italian. Vision, as near as could be estimated from picture charts, 20/CL. Static skiascopy, O. U., + 5.00. Dynamic skiascopy, O. U., + 8.50. O. U. + 300 gave about 20/LXXX vision. Had this boy under observation, monthly, for five years. No change during that time in vision or in skiascopic findings. Changed lenses at different times. Part of the time had him wearing bifocals. Tonsils, teeth, digestion, nutrition, O. K. No syphilis. When he was 12, tried base-out prisms. O. U., + 3.00 D. Sph. () 3.00 △ base-out, vision 20/XXX. Wore these one week, vision 20/XX. Reduced prism to 1 △, O. U., leaving the + 3.00 D. Sph. A month later, removed all prism. One year later, at the age of 13, had a normally functioning pair of eyes. Vision without glasses, 20/LXXX. Vision with O. U. + 3.00 D. Sph., 20/XX.

Woman of 56. Desk worker, great deal of suffering and headache. American, of New England farmer descent. Pupils large. 4 △ of exophoria at distance, 8 △ exophoria at near. Corneal astigmatism and this varied in amount and axis constantly. Often changed glasses weekly on account of the shifting axes. No pair of glasses would be usable more than a month. Static skiascopy, O. U., + 4.00 D. Sph. with about + 0.75 cylinders, whose axes could be seen to shift to 90 degrees and then away, to either side. Dynamic skiascopy, O. U. + 7.00 D. Sph. with the same vagary on the part of the cylinders.

Accepted O. U. + 3.00 D. Sph. () + 0.75 D. Cyl., with 20/XL vision. Add, O. U., + 2.50 D. Sph. Gave base-out prism exercises, which improved comfort for near. Later, added 1 △ base-out, O. U., and that turned the trick. Vision came up to 20/XX in about six months.

There is no literature to be had on this subject. It seems to have been completely overlooked. No one seems to have ever thought of it. But here it is and this seems a fair solution. It is a subject that must be given much more study. Between Dr. McCulloch and myself, I think we have now upwards of a hundred of these cases on record. We have been following this procedure for four years with satisfactory results.

In 1921 I established a free clinic for poor children, mainly to get material with which to experiment. I was struck with the fact that so many had poor vision and that, while plus was indicated by the skiascope, plus spheres would not improve vision.

Every explanation was offered by different specialists. Some said, "Have their tonsils out." We did. It made no difference. Others said, "Congenital syphilis," but it was not. Almost everyone said, "Give them the plus correction and they will develop vision." We did that, but they did not develop vision and after several years of wearing such lenses there

would be no change in vision nor in skiascopic measurements. I now think those spheres were harmful, that the children would have done better without them. I think this is what Dr. Rogers had in mind when he said in his book, "Beware of too much plus for children for it stops the growth of the eyeball." The plus stops the development of the convergence-accommodation function.

It was not until the spring of 1924 that I got the first clue. And when I did succeed, the whole thing seemed incredible. I hesitated to try it out on more than an occasional case, and kept very close watch of these. After I found that such treatment was successful, I became emboldened and finally concluded that this is the proper treatment for such cases.

These are the cases where such wonderful success has been reported in the past by base-out prism exercise enthusiasts. This is the only type to which we give either base-out prisms to wear or base-out exercises. Many times, exercises alone will do the work without the necessity of wearing any glasses whatever.

These are the cases that have been called "Premature presbyopes." We doubt very much if there is such a thing as "premature presbyopia." The term originated, as did so many of our unauthentic terms, from a lack of actual study of ocular functions, of the fiber tracts of the brain, of dependence on fallacious theory.

The Ophthalmometer

One of the more outstanding weaknesses in our corrections of optical errors of refraction, is the general failure to fully correct the corneal astigmatism. The custom that has grown up of using minus cylinders is perhaps one of the reasons for this. This custom, I believe, had its origin in the days when comparatively few refractionists owned ophthalmometers, and the ophthalmometers of that day were not very good instruments. The use of cylinders even was not so very common, there were many who did not bother to correct such small errors as half dioptres.

The earlier method of correcting astigmatism was to put on whatever plus or minus sphere would give best vision and to then try cylinders, if vision was not brought to 20/XX with spheres alone.

Thoughtful men realized the inadequacy of this and found that if they would fog vision down with plus spheres and then correct the astigmatism with minus cylinders, they got on more cylinder than by the other method. It was an advance.

As the art of skiascopy developed, this method was carried along with it. The custom, which is in general use today, was introduced. That is, to first neutralize the meridian of greater error with plus spheres in hyperopic cases, then use minus cylinders to neutralize the other meridian. The

day of plus cylinders was said to be doomed. One of our prominent theorists even advocated the elimination of plus cylinders from the trial case.

The man who invented the ophthalmometer, Javal, seems to have had a better understanding of astigmatism than many of his successors. He laid down a rule, "Add 25% to the ophthalmometer and deduct a half dioptre." Someway or other, the "add 25%" part of his rule got lost. The custom became, "Deduct 0.50 from the ophthalmometer reading." This is erroneous. And if we use the generally advocated minus cylinder method, our corrections come far short of the Javal rule. The reason of this is hard to explain. Some say that the sphere covers a part of the astigmatism. Some say that sectional accommodation enters. Others propose different explanations, all having to do with supposed activities of the accommodation. None of these postulates have been proved or disproved. We are still in doubt.

But we do find that if we put the plus cylinder on, as indicated by the ophthalmometer with the Javal rule's allowance, and put this plus cylinder on before we attempt the spherical correction, that it is quite generally accepted. We set this cylinder in place before commencing our skiascopic test. We then find, as a rlue, that our skiascopic reflex is spherical, all we have to do, generally is to supply that sphere, either plus or minus, that neutralizes the shadow movement. But now and then there are exceptions and it is these exceptions that awaken our curiosity.

Now why do we add 25% to the ophthalmometer findings? It is because of the distance of the lenses from the cornea. Why do we deduct 0.50? Some say "lenticular astigmatism." But that is wrong. The reason is that the visual axis passes obliquely through the cornea, introducing the factor of radial astigmatism, or astigmatism due to oblique incidence.

The optic axis of the eye, like the optic axis of any lens system, is a line drawn through the center of the lenses. In the eye, this line is from the pole of the cornea to the posterior pole of the eyeball. But we do not, in fixing an object, look along this line. For the macula and fovea are to the temporal side and a little below the posterior pole of the eyeball. Hence, the visual axis, from the fovea to the object, passes out, not through the pole, or center of the cornea, but a bit to the nasal side and a bit above this center. So this visual axis passes obliquely through the spherical curve of the cornea.

The angle formed by the visual axis and the optic axis is called the angle alpha. It is generally about 5 degrees. When it is 5 degrees and when the base curve of the cornea has a radius of 7 to 7.5 mm., the resultant radial astigmatism is approximately —0.50 D. Cyl. Ax. 90. Hence, the deduction of 0.50 when the astigmatism is with the rule, the addition of 0.50 in astigmatism against the rule.

If the cornea is of greater curvature than this, the amount of radial astigmatism is correspondingly greater. In the very high curves it amounts to enough more than 0.50 to make the deduction greater. When the corneal curve is much less than this, the deduction is less.

The angle alpha is not always 5 degrees. Many times the fovea is not at the ideal spot. Then the angle alpha is greater or less than 5 degrees, with corresponding increase or decrease of the radial astigmatism, correspondnig greater or less deduction than 0.50.

Given a high curve base curve of the cornea with a high angle alpha and the radial astigmatism is sufficient to compensate for quite a high degree of corneal astigmia.

This is chief reason for the variations sometimes found, when the patient will not accept the ophthalmometer findings modified by the Javal rule.

But these cases are not so very common. If we use plus cylinders, if we put those cylinders in place before attempting the spherical correction, we shall, in the great majority of cases, find them accepted. One advantage of the streak method of skiascopy as developed by Dr. Copeland is that the use of plus cylinders is compulsory. The use of minus cylinders was an advantage in the days of cruder instruments and cruder methods, but that day has passed. Their continued use is without excuse and is erroneous.

Some of the old ophthalmometers were not correctly scaled. To make an instrument that can be used on all curvatures, the dial scale must be compensated, the divisions on the dial must be of different widths for different curves. All present-day ophthalmometers are so compensated, this element of error is practically eliminated.

Use the ophthalmometer. Be guided by its findings. Apply the Javal rule. Use plus cylinders. Your refracting will be more accurate, more satisfactory.

In the earlier days we were taught that corneal astigmia is congenital, that it does not alter, that a person remains astigmatic through life. But when we refract the same person year after year, we find this is not true. The amount of corneal astigmia does vary, the curvature of the cornea varies at different periods of life, varies in sickness and in health.

We find that in healthy adults, there is a tendency for the cornea to become flatter with increasing age, as general body tonicity decreases. There is also a tendency toward decreasing the corneal astigmia with the rule. So that, as our patients grow older, when they are in good health, the needed cylinder is less.

We find that in adults with certain digestive disorders, especially hyperacidity of the stomach, the tendency is for the cornea to increase its curvature, for astigmia with the rule to become greater.

This gives us a diagnostic point of considerable value. When we find a patient whose corneal curves are greater than at the last examination, we should immediately refer him to a competent physician, better to a modern alimentary specialist. If a patient comes in today and the ophthalmometer shows a primary meridian curvature of, say 44, and our records of two years ago, or of one year ago, shows that the curve in that meridian was 43, it is our duty to advise him of the dangerous physical condition he is in, to insist that he visit the proper specialist at once. If we find the amount of astigmia increasing, we have that same warning.

As the curve of the cornea decreases with advancing age, we find more plus sphere needed for sharp vision. When the curve increases, less plus, or more minus, is needed. Healthy people grow more hyperopic, as a rule, as they grow older. They never grow less hyperopic.

There is another value in the ophthalmometer readings that I do not find mentioned in our literature. If the primary meridians of the two eyes are of the same curve, then we shall expect that the spheres accepted by the two eyes will be of the same power. If skiascopy and subjective tests show the spheres are different, then we suspect something is wrong. For example, say the primary meridians are both 42 D. If the right eye shows a manifest error of, say, 0.25 D., while the left eye shows a different spherical error, say, 1.00 D., then we should be suspicious. Use your strong base-in prisms to disclose the latent hyperopia and you will find that the true refractive error is the same in the two eyes. This will happen in better than nine cases out of ten.

Dynamic skiascopy, for all the claims that are made for it, will not reveal the true error in these cases. Atropine will not always do it. For atropine inhibits the innervations of only one of the three muscles that make up that which we call the ciliary muscle. If there is a contraction of the meridional fibers, permitting the crystalline lens to convex, atropine cannot inhibit the innervation of those fibers.

When the primary meridians of the two corneas are not alike, we expect different spherical corrections for the two eyes. If skiascopy and subjective testing show the same sphere for the two eyes, then those findings are at fault. For instance, let us say that the primary meridian of the right eye is 43 D., the primary meridian of the left eye, 44 D. But we find, say, + 1.00 D. Sph. for both eyes. This will be wrong, almost always. Use the strong base-in prisms, inhibit the convergence-accommodation, and you will find that the eye with the lower curve, in this cited case, the right eye, requires the stronger plus.

The more we learn, the more valuable does the ophthalmometer become to us. But we need one more instrument. It is not an easy task to make this instrument. We need apparatus for measuring the angle alpha. Until that is given us, we cannot correct astigmatism exactly. Then we shall need yet another instrument, something with which we can measure the tilting

of the crystalline. For such tilting is not rare and it doubtless introduces an astigmatic problem. We do not even know how and why the crystalline is tilted. There is a problem the student of the future must solve.

In myopia, the corneal error is liable to sudden, sometimes quite large, changes. We find that the tendency of base-in prism exercises and base-in prism wearing is to lessen the corneal astigmia. When we give exercises, we must take the ophthalmometer readings before we start with the exercises and again after their conclusion. If we give daily exercises, we must take two ophthalmometer readings daily. Sometimes the corneal curve and the amount of astigmia change during the examination.

In some other imbalances, mostly those connected with visceral disturbances, we find that the corneal curves alter very rapidly.

In esophoria with latent hyperopia we very often find changes, not only in the amount of the corneal astigmia but in the axis. This is particularly true when there is a high manifest left hyperopia of right-handed persons or a high manifest right hyperphoria of left-handed persons, which is quite common among esophores. The shifting axes become stationary, the amount ceases to vary, the hyperphoria disappears, when we get on the full plus correction with some base-in prism.

The same is true in adult cases of arrested development of the convergence-accommodation function. Amount and axis continually alter. But this uncertainty ceases when we give base-out exercises and base-out prism to wear.

We note that the general tendency of giving base-in exercises is to reduce the amount of corneal error. But I had one case, only one, where the corneal astigmia increased following base-in exercises. Sometimes the corneal astigmia increases with base-out exercises, but this is not so common as the decrease with base-in exercises. In cases of latent hyperopia with small pupils, we do not find changes of corneal astigmia following base-in exercises. Whether base-out exercises change the error in these cases I do not know. For it is inadvisable to give base-out exercises to the latent hyperope, so I have not cared to make the experiment to see what might happen to the corneal curves.

Hyperphoria

We find that it is not sufficient to say a patient has right or left hyperphoria, but we must qualify this by stating the handedness of the patient. For a right hyperphoria of a right-handed man is a totally different proposition from a right hyperphoria of a left-handed man.

We shall not here discuss the hyperphorias caused by toxemias. They are in a class by themselves.

We find there are a great many subdivisions of hyperphoria, some needing one treatment, some another. Many of these we have but recently segregated, have not yet learned the best way of treatment. I shall only set

down the particular ones that we have successfully mastered. The reader must carefully note the distinguishing features of each, must not confuse these types with each other nor with other hyperphorias with slightly different combinations that he is bound to find, if he is a careful observer.

Hyperphoria with esophoria with latent hyperopia. The right-handed person shows left hyperphoria, the left-handed person shows right hyperphoria. Ignore the hyperphoria, unless there is also habitual head tilting, a subject we shall discuss in a separate paragraph. Give base-in prisms. Correct the plus in full. The hyperphoria will disappear. The vertical ductions will be less unequal when tested with the plus correction in place than when tested without the plus correction. Sometimes the vertical ductions become equal immediately. They will be equal, in all cases, after wearing the base-in prism and full plus correction for a few weeks.

Hyperphoria with esophoria without high latent hyperopia. The right-handed man showing right hyperphoria, the left-handed man showing left hyperphoria. This has been discussed under "Esophoria without latent hyperopia." Correct the manifest hyperphoria. Ignore the esophoria. It is better to divide the correcting prisms between the two eyes.

Hyperphoria with exophoria. The right-handed man showing left hyperphoria, the left-handed man showing right hyperphoria, without habitual head tilting. If there is no head tilting, if the head is habitually carried erect, suspect latent hyperopia. Correction of this, wearing the needed plus, with or without base-in prisms, as the case may require, will take care of the hyperphoria.

Hyperphoria with exophoria. The right-handed man showing right hyperphoria, the left-handed man showing left hyperphoria. There are four distinct types.

1. Pupils large. Arrested development of convergence-accommodation. Give base-out prisms. Ignore the hyperphoria.

2. Pupils normal. High exophoria at near. Correction of the hyperphoria, "prisms in so-called position of rest," may decrease the exophoria. If so, prescribe the vertical prisms. Ignore the exophoria. This type is rare.

3. Pupils normal. High exophoria at near. Correction of the hyperphoria increases the exophoria. Try prisms in the reversed position, weak base-up over the right eye for right hyperphoria, weak base-up over the left eye for left hyperphoria. This usually decreases the exophoria. This type is common. The hyperphoria disappears and the exophoria is permanently less after about a year of wearing these prisms.

4. Pupils normal. Vertical prism of any amount and in any position increase the exophoria. Then 1 △ or 2 △, O. U., bases-in, will eliminate the hyperphoria. This type is rare.

Head tilting. Right-handed man, left hyperphoria, habitual left head tilt. Give base-up to the left eye, base-down to the right eye. The head will be held erect.

Head tilting. Left-handed man, right hyperphoria, habitual right head tilt. Give base-up to the right eye, base-down to the left eye. The head will be held erect.

Do not correct hyperphoria of the two above types with prisms "in the position of rest." The hyperphoria will increase. The head tilting will increase. The patient's function of equilibration and orientation will be seriously impaired. Give "reversed prisms." The head will be held erect. The functions of equilibration and orientation will be greatly improved. This hyperphoria has developed as a compensation for the head tilting, and is incited by the equilibration mechanism of the labyrinth to bring visual sensations into harmony with labyrinthine sensation.

There are other combinations of right or left-handedness with right or left hyperphoria with right or left head tiltings. We have some of these types now under observation but are not prepared to make any statement whatever concerning treatment methods.

Possibly some of you, with these hints of the involvement of the factor of handedness in hyperphoria may be able to solve some of these mystifying imbalances.

Ductions

It seems that we were not quite right in assuming that ductions represent "muscle reserves," or "nervous reserves," or "pulling power of muscles," or "fusional reserves," or "convergence reserves," or reserves of any sort.

Every muscular activity is conditioned by a great many factors. One is the normal association of the muscles in functions they regularly perform. Another is the habit of the individual in using his muscles in a certain way to do the tasks he wishes them to accomplish. Another is the control of the cerebellum in maintaining synergy, or balanced innervations and inhibitions; if something goes wrong in these pathways, the effectivity of the muscular co-ordinations is impaired; Another is the reciprocal tonicity of the muscles antagonizing each other; if one is hyper-tonic, the other hypo-tonic, efficient rearranging of these muscles in new act is impossible. Another is the general condition of the health. Another is any acute affection of some of the vital organs, especially such a condition as acute indigestion, or such a permanent condition as hyperacidity of the stomach; in its struggles to care for this, the entire nervous system is upset; then muscular acts all over the body are liable to derangment. Another is mental disturbance, fear, anger, worry, anxiety, and so on; then muscle associations are liable to inco-ordina-

tion. Mental disturbances create toxins just as surely as do decayed teeth or clogged colons. The factors leading to loss of associated control over muscles, or to inability of the central nervous system to command new associations, are almost innumerable.

All these are factors involved in the freedom or lack of freedom that we find when we take the ductions.

For example: The only innate binocular function is the associated turning of the two eyes up and down. The only time that we dissociate this function is when we tip the head to right or left. If we tip to the right, the right eye is turned up and the left eye is turned down. If we tilt to the left, the left eye is turned up and the right eye is turned down. But this is not a reflex arc in response to a visual sensation. It is a reflex arc incited by the equilibration mechanism, in order that the visual sensation shall agree, in its message to the cerebellum, with the messages sent from the equilibration sensory organs in the vestibulum. The eyes are turned before we consciously "see," to prevent loss of orientation.

But when we take the vertical ductions, the head is erect. We are asking that the central system turn one eye up and hold the other still, if we are using prism over one eye only. Or, if we are using prisms over both eyes, we ask that one eye turn up while the other turns down. And we are asking that act as a response to a visual sensation. So we, asking the central system to do something it never did before, to break up old habits, an innate association, ages old, and perform an entirely new act, create, on the spur of moment, an entirely new association of muscles. The success with which this is done is shown by the result of the vertical duction test. The things that impede it, if there are any, will cause low ductions. Liberty of action, ability to make new associations, freedom from other tensions, will be shown by high ductions.

The same general principle applies to the horizontal ductions. Taking the induction or abduction with prism over one eye is interfered with by that normal association that turns the two eyes together to right or left, when perhaps only one delivers a sensory impulse. That happens when an object is so far to the right that only the right eye sees it, or so far to the left that only the left eye sees it; yet both eyes turn. Cover one eye, follow a moving object with the uncovered eye; the covered eye turns in association. We do the same thing with prism over one eye, we awaken a sensory stimulus from one eye only. Yet we ask the central system to turn that eye and hold the other still. It has quite a job doing it, as we have demonstrated in laboratory experiments. The success with which it accomplishes this difficult task is shown by the amount of prism overcome in the test.

Without discussing this very interesting subject further, let us say at once what the ductions are: They are a measurement of the central nervous system's ability to bring muscles into new associations, associations never before required. High ductions represent flexibility, facility in making new associations, freedom from stresses and tensions. Low ductions mean tension, stress, disturbance.

We can find no diagnostic value to the induction test with base-out prisms, in spite of all that has been written and said on the subject. We are hoping, as we learn more, to find just exactly what its usefulness is. We have learned this, that it is exceedingly dangerous to take the induction of an esophore or a myope. We handicap our own efforts, make difficult that which we wish to do. What we want in those cases is relaxation of convergence-accommodation. Base-in prisms force that relaxation. Base-out prisms excite more tonicity in muscles that are already hyper-tonic, make more difficult our task of relaxation.

Ductions should always be taken with prisms of equal amount, and changed at the same moment, over both eyes. There is a physiological law behind this. We have demonstrated, by laboratory work, that it is far more difficult for the central system to break down associations with prism over one eye, getting a sensory impulse from but one eye at a time, than it is when we use prisms simultaneously over both eyes and incite reflex arcs simultaneously from the two eyes.

The value of the abduction test has been shown in the discussions of esophoria and myopia. One more point on these. If abduction is high in hyperopic cases, expect to find considerable latent hyperopia. Also, these cases will prove comparatively easy to handle when it comes to getting on the full plus correction. If abduction is low, it may be due to the stress occasioned by compensating for a high latent hyperopia, or it may be due to disorders in the digestive or sexual organisms, or it may be due to worry or some other mental distress, or it may be due to the presence of toxins in the blood stream.

If abduction is high in myopic cases, you may know that you will reduce the manifest myopia considerably. If the abduction is low, you will not get much reduction.

Ductions are low in esophoria because of the hyper-tonicity of one set of muscles and hypo-tonicity of their antagonists.

I hope that this paper will arouse in you the realization of what a vast deal of work must be done before refraction can emerge from its present state of a guess work method of handling binocular problems. If we can only become discontented with our present hazardous position, with the illusive instruction our teachers have thrust upon us, if we can only, as a body of practitioners, organize to seek facts, not theory, then our profession can become of greater service to the advance of civilization, to the development of industry and the arts, than any profession that has yet arisen.

Date Due